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POTENTIAL ROLE OF REMOTE SENSING IN DISASTER RELIEF MANAGEMENT

THE UNIVERSITY OF TEXAS
HEALTH SCIENCE CENTER
SCHOOL OF PUBLIC HEALTH
HOUSTON, TEXAS

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by

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Chapter 1

MANAGEMENT OF DISASTER RELIEF:

STATEMENT OF THE PROBLEM AND PROPOSED SOLUTION

What is the problem?

Examples of the mismanagement of disaster relief abound. Probably the most typical situation is the inundation of a disaster area with unneeded resources (Rennie, 1970; Faich, 1973). While inundation of the area with supplies is to some extent a political phenomenon, another factor which contributes to this situation is the lack of accurate information in the early phases of a disaster on which to base an assessment of relief needs (Department of Defense, 1967 and League of Red Cross Societies, Steering Committee, 1975). Arranging for the distribution of relief goods within the disaster area, once needs have been identified, often is not planned (Rennie, 1970; Kroger, 1971; Faich, 1973, League of Red Cross Societies, Editorial, 1975). Thus, although not anticipated, attempts to alleviate the results of a disaster frequently contribute to already existing problems (U.S.D.H.E.W., 1974). The public health of a stricken community depends on the smooth functioning of relief activities and on the rapid restoration of service systems in the community.

Evidence shows that mismanagement problems are commonly caused by a lack of knowledge and/or skill of the work functions required to manage disaster relief (U.S.D.H.E.W., 1974). Disaster plans, where available, often fail to outline the relief functions and tasks sufficiently so that even experienced personnel do not have a clear overview of what needs to be accomplished. Since, in a given community, disasters strike

infrequently, it is likely that people with some prior experience in disaster relief management will be scarce or unavailable. Also the nature of disasters that affect communities is likely to change so previous experience may not be specifically applicable. Lack of knowledge is an even more acute problem for inexperienced personnel.

Most city and state Standing Operating Procedures (SOP) for disaster relief management begin with the assumption that decisions about the type and quantity of the resources required to minimize the disaster impact have been made. These SOPs generally list the responsibilities of various agencies and describe how to implement tasks. For example, as stated in one city SOP, the Department of Public Health has responsibility for providing medical care and treatment for the ill and injured. This plan assumes that decisions about whether or not medical attention is actually needed and whether or not local facilities are adequate to handle the emergency have been made. We have not found evidence to support the belief that these decisions are made in a systematic way. In other words, disaster plans, where they exist, have been organized around decisions that have not been made explicit. Further, as mentioned, it appears that information on which to base decisions of this type is not easily available.

Unless SOPs detail tasks by functions rather than by agencies, fragmentation and duplication of effort may result because restoring certain systems following a disaster frequently involves several agencies. For example, checking and restoring the water system and supplying water may involve the Division of Engineering Services which is responsible for checking and repairing the system, the Health Department which is required

to test for contamination, local government which distributes water to areas where the supply has been cut off, and the Department of Safety and Transportation for movement of water tanks.

A more holistic approach to disaster relief management--one that has been adopted in some states--is to diagram work functions without consideration of agency boundaries, and this also is the approach of this guide. In order to manage disaster relief functionally, it is important for the agency heads to be together at a central location such as an Emergency Operation Center (EOC). The single most important item needed to make decisions and set priorities in the postdisaster period is accurate, timely, and detailed information (Harrison, 1973). Collection of information following natural disasters is accomplished primarily by field survey.

Information comes from the lowest working level on the scene and may go to various control centers depending on the magnitude of the disaster. In some disasters, there may be several levels of decision making. For example, tornado damage may stay within city limits or extend into one or more surrounding counties. If the damage is within the city limits, the various city-level agency heads in addition to the city EOC director, if there is one, would form the main control center or decision-making body. If the disaster affects the county, county and state agency personnel would be involved. Thus, there could be more than one decision-making center. A hurricane is a good example of a natural disaster in which many decision-making centers become activated. Several cities and several counties are likely to be affected by these storms, and each city and each county may have its own control center. In addition, in a

disaster of this size, the state decision-making center would also be involved. Disaster relief managers include those persons at all levels of government who are responsible for planning intervention and response measures and for making decisions, allocating recources and setting priorities in the immediate pre- and postdisaster period.

Information usually is transmitted to the control center by either radio or telephone, and data may or may not be recorded, processed and analyzed in a systematic way. Many departments and/or agencies utilize the same information. If information could be accumulated, analyzed and distributed early in the acute relief process, repetition could be avoided and more effective decisions could be made. One way of ensuring the orderly transmission of information is by simulation exercises which may be conducted at various levels of government such as the county or city level. Such practice exercises have become a part of disaster planning in some states such as Texas.

While the field survey procedure of data gathering eventually leads to accurate and complete data, in a large disaster it may take several weeks to refine the estimates until they are accurate. For example, the Red Cross gathers information on number of persons dead, persons with injuries or illness, and persons hospitalized as a result of the disaster. If early accurate estimates of these data could be made, the provision of medical services could be managed more efficiently. Information on degree of damage to residential structures (single-family dwellings, mobile homes, and apartments) and to small businesses is also collected by the Red Cross. Immediate information on extent of damage would enhance accurate estimation of the number of shelters and the amount of

food required to service the population in the disaster area. Information pertaining to the recovery of other functions such as water and sewerage is currently gathered by the time-consuming method of field survey. Transportation is another example where a timely overview of the damage would result in more efficient allocation of resources and setting of priorities.

The Red Cross uses census data as a base from which to make initial estimates of property damage in a large disaster such as a hurricane. Obtaining the first estimate in a city the size of Houston, Texas takes from 24 to 48 hours, but the first estimate is usually not very accurate. As soon as conditions permit, teams composed of volunteers survey the area and assess damage scored as major or minor on a house-to-house basis. Some information items are obtained from other agencies such as police, fire, civil defense, and insurance companies. After a large disaster, it would take about 1,000 volunteers approximately 2 or 3 weeks to survey a city the size of Houston according to Red Cross personnel. If more volunteers were available, the initial stages of the survey--such as identification of the communities affected--could be expedited, but completion of the survey would still require about 3 weeks.

The amount of time required for the Red Cross to produce an estimate of the number of ill, injured, hospitalized and dead depends on the availability of communication service as well as on the number of volunteers. It would take 3 to 5 Red Cross nurses about 3 or 4 days to make these estimates following a major hurricane in a city the size of Houston.

It seems clear that a need exists for a method of gathering and analyzing data quickly following a natural disaster with a large areal

extent. These data would enable disaster relief managers to make decisions based on accurate, timely and detailed information and thus their actions can be related more specifically to circumstances in the postdisaster environment. This guide proposes a supplemental or alternate means of data gathering called remote sensing.

This guide discusses only those postdisaster relief activities that affect public health either directly or indirectly. Six service systems are identified which are believed to represent major public health concerns following natural disasters: medical services, water supply, liquid waste disposal, shelter, food, and transportation. Problem-solving contingencies are elaborated within a decision-making framework identifying what has to be done to "solve" a problem created by a natural disaster. It is assumed that an emergency communication network has been planned and will be promptly established in the postdisaster period since this function is a prerequisite to coordinating the delivery of relief activities.

What is remote sensing? What is its role in disaster relief management?

Remote sensing is "the acquisition of information about an object (or phenomenon) which is not in intimate contact with the information-gathering device" (Parker and Wolff, 1965). It is a means of extending our capacity for perceiving at a distance without being in direct physical contact with an object through the use of specialized instruments such as cameras and radar (Parker and Wolff, 1965). Weather radar, weather satellites, seismographs, sono bouys and videotape are examples of remote sensing systems.

Another form of remote sensing is aerial photography. When combined with photo interpretation it becomes a method of data gathering which can

provide useful information to disaster relief managers. Photo interpretation is "the examination of images of objects on film for the purpose of identifying the objects and deducing their significance" (Naval Reconnaissance and Technical Support Center, 1967). This type of remote sensing may be viewed as one of the data gathering and information-producing techniques available to disaster relief managers. This tool may provide information to make decisions in a shorter period of time than current methods. Aerial photography can gather much of the information needed to set priorities and to implement the steps necessary for disaster relief to be delivered in an effective and efficient manner. With visual information immediately available, the disaster relief manager can make decisions which reflect a more accurate and complete assessment of the situation. This method of data gathering can be used to supplement present disaster plans, or it may prove feasible in some cities to organize disaster plans around this data gathering technique.

<u>What are the advantages of remote sensing, especially aerial photography?</u>

A photograph gives an overview of an area to show the geographical extent of damage. The damaged area or sites can be identified quickly in relation to resource areas outside the community.

A more detailed analysis provides a breakdown of the damaged area into subareas with different degrees of damage. Priorities may then be set in terms of damage severity.

Specific categories of concern can be isolated on photographs for different relief and restoration operations. For example, transportation routes, utilities, residences and other structures can be examined

separately for persons with those areas of concern. Higher priority may then be assigned to crucial sites and areas with higher chances of secondary effects such as fires, landslides and tidal waves which may accompany earthquakes.

Time is a most important resource immediately following a disaster. If time spent in gathering information on which to base decisions can be condensed, early preventive measures, relief and restoration may save lives and property. If accurate photographic data can be made available more quickly than data gathered by other current methods, then photo data offer an important advantage.

In special circumstances, field observation may not be immediately possible. In such cases, photographs or some other form of remote sensing may be the only means of obtaining information. For example, fire, high water or radiation may keep persons from the disaster scene.

Photographs can be an immediate and accurate information source of both pre- and postdisaster conditions. Communities can be photographed under normal circumstances to compare with postdisaster photos. They can also be used in the planning and prevention stage of the anticipated disaster. Photographs of past disaster conditions could be used, as well. For example, floods could be photographed in order to predict the most likely future flooding patterns taking into account interim preventive measures.

Finally, a permanent record of the damage can be kept. This allows the photo interpreter to review the photographs for greater detail to monitor the restoration progress.

In summary, photography may provide: (1) an overview of the disaster scene to determine its extent; (2) a geographical distribution of severity of damage; (3) a common source for information about different service systems; (4) a possible savings of time in gathering information; (5) the only data source under certain conditions; (6) a source of objective information for decision making both prior to and after the disaster; and (7) a permanent record for more detailed analyses (Photograph 1).

Although the pattern of damage may vary with the type of natural disaster, this does not affect the process of photo interpretation. The same system can be utilized for any natural disaster that results in observable, physical damage.

<u>What is needed to put this system into operation? Where can it be obtained?</u>

The elements required to make this system work include an aircraft, camera(s), cameramen, film processing personnel and equipment, a photo interpreter, and photo interpretation equipment. Selected technical information about types of film and cameras appears in the Appendix. The sophistication of this system varies depending upon equipment. The following systems illustrate decreasing levels of sophistication: a military airplane with several mounted camera systems using a variety of film types, videotape system, an observer in a helicopter or small plane using a handheld camera or simply recording information on a map or in a log.

A means of acquiring remotely sensed data must be arranged in advance of a natural disaster. Sources of photographic data which would be useful in the postdisaster period are reconnaissance wings of the military, government agencies (e.g., NASA), and commercial firms that specialize in aerial photography. Arrangements must also be made to have the photographs

(Cont'd. on Page 11)

PHOTOGRAPH 1

XENIA, OHIO TORNADO

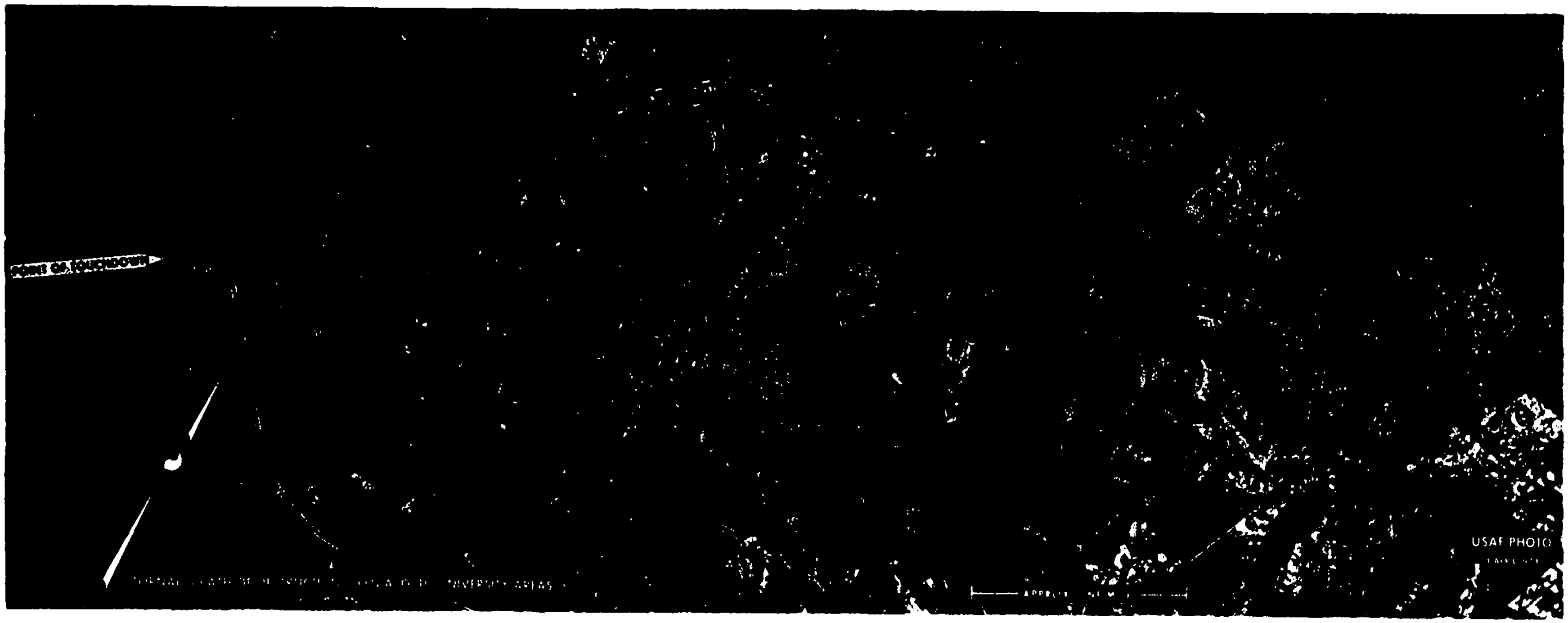
Photograph 1 is a small scale (approximately 1:73,000) vertical black and white photograph of Xenia, Ohio, after the tornado in April, 1974. This scale shows an overview of the tornado path. With good quality film this photograph could be enlarged approximately 10 times allowing a viewing scale under a microscope of approximately 1:7,000. In the immediate postdisaster period, the photo interpreter would be working from film positive transparencies, and information probably would be communicated to disaster relief managers verbally, in tabular form, or on maps. Photographs with overlays would be available at a later stage and could be used for planning restoration and monitoring progress. (For a discussion of film scales, see Appendix.

An experienced photo interpreter can determine the spatial extent of the disaster and a geographical distribution of severity of damage in broad categories such as severe and minor. Damage to transportation routes and structures (roads, railroads, bridges, airports), can be seen as well as broad categories of land use (residential and large commercial areas), but specific types of structures (school, house, business) are difficult to identify at this scale.

A small scale photograph may also be useful for preplanning purposes. For example, it indicates major transportation routes for evacuation if needed and an overview of population distribution. In addition, information from other sources can be compiled to make overlays marking important sites and resources in the community such as hospitals, fire stations, shelters, warehouses, etc., for comparative use in postdisaster analysis.

Source: U.S. Air Force Photograph. Calvin B. Olsen, consulting photo interpreter.

PHOTOGRAPH 1



interpreted. Photo interpreters' skills are probably available through the above-named sources, and this should be planned in advance.

It may be possible in some states to arrange for the military to overfly and photograph the disaster area. For example in Texas aerial reconnaissance may be requested from the Air Force by the State Emergency Operating Center following a disaster. These arrangements are informal but may be formalized in some states. In California, a memorandum of agreement exists between the State of California (Office of Emergency Services) and NASA (Administrative offices) under which NASA (Ames Research Center) flies disaster areas and provides photographs. The operating liaison is effected directly between the Office of Emergency Services in Sacramento through which requests are channeled, and NASA/Ames located at Moffett Field. If government sources are not available to disaster relief managers, contracts may be made with local commercial aerial photography companies. If this option is used, a minimum six months planning period is recommended in order to develop a detailed contract with explicit instructions and costs.

The costs and time involved in utilizing aerial photography in a disaster relief situation will vary according to the number of flights, the sophistication of the equipment, the type of film (infrared or regular, color or black and white), the extent of the area photographed, and the detail of the information needed by the disaster relief manager. For example, to film a disaster using military planes and equipment takes approximately two hours to get airborne, plus flying time to and from the disaster site, with time to film the disaster. Black and white film can be processed at the rate of about 15 feet per minute. The time required to

perform photo interpretation varies with the size of the area, the number of photo interpreters, the complexity of the area (e.g., density of structures), and the facilities available (e.g., light tables, etc.). A cursory analysis of a city the size of Austin, Texas (1000 square miles/ 250,000 population) would take one experienced photo interpreter who was familiar with the area about three hours (150' of film) using photography at a scale of 1:18,000. Crew members can aid the photo interpreter by defining their actual flight route, identifying where they started to film (frame number), and specifying where the heaviest damage begins on the film.

For these data to have an impact on disaster relief management a communication network must exist so that disaster relief managers can receive information. It is a prerequisite that everyone involved--disaster relief managers and remote sensing personnel--have the same information base (e.g., maps) in order to establish common reference points for communication. Maps of the affected area need to be immediately available to all department heads and relief workers who are assessing local conditions and relaying such information to a central point. Relief workers dispatched for picking up the injured or alleviating threatening conditions must also be supplied with accurate maps that are uniform in scale and have common map coordinates. Such maps are necessary for locating areas of disaster conditions in relation to important sites within the affected community such as pumping stations or hospitals.

In order to use aerial photographs to their maximum potential, certain information about the predisaster area must be available. This information may be obtained from predisaster photographs or from maps.

Predisaster photographs enable the photo interpreter to identify signatures on a disaster photograph more rapidly by clarifying questionable structures in areas where heavy damage has occurred. Photographs with overlays also can be used as a base in place of maps for locating damaged areas or sites in the immediate postdisaster survey. An already existing or an arbitrary grid constituting the location system could be superimposed on a predisaster photograph or overlay as well as on maps. Each grid square can be identified by a number so that all persons involved in relief activities have a common location basis. The baseline data or predisaster information and maps which would facilitate disaster relief delivery are discussed in Chapter 3. A way of organizing these data to incorporate the use of aerial photographs is detailed. The recommended baseline data and predisaster photos would expedite the relief process with or without the use of postdisaster aerial photographs.

What are some of the limitations of aerial photography?

Aerial photography is one of the tools of a disaster relief manager, but it may not be applicable in all disaster situations. A community needs to consider the use of this system in relation to the following variables. Size of the disaster is an important determinant in whether or not to use aerial photography. Field surveys may be the most timely source of information in small tornadoes and localized flooding. However, for hurricanes, major floods, and earthquakes photography may provide more timely and accurate information.

Communication networks, weather conditions, predisaster planning, and equipment available (aircraft, cameras, film, processing and interpreting facilities, and special personnel) are variables in this data gathering

and information system which may limit its availability and use. For example, the clarity of photographs will depend on the type of film, the altitude of the plane, photographic equipment, and weather conditions at the time of flight. When using government aircraft, response is dependent on the availability of aircraft, the presence or absence of the appropriate sensors in the aircraft, and the ability of the photo lab to put aside other work in order to process the disaster film.

Other limitations of using aerial photography include problems associated with photo interpretation. For example, an earthquake may not be so severe as to noticeably damage the external structure of a building, yet it may be strong enough to break sewer and water connections and damage the internal structure and contents. Floods are another example of a situation where, unless photographs are taken before the water recedes, damage may not be apparent. In some situations, even external physical damage may not be apparent from certain photographic angles. For example, a tornado may blow roofs off buildings and set them on the ground. From vertical photography, the structure would appear to be intact. Oblique photos would be needed to reveal this type of damage.

What is the purpose of this document?

This document suggests procedural guidelines which can be used for planning and organizing public health relief activities in the immediate postdisaster period and points out where aerial photography may be beneficial. The generic functions that officials need to perform or consider to manage these activities more efficiently and effectively are outlined. This guide includes a description of:

1. WHAT functions must be performed to manage adequately a disaster;

2. WHEN (in what sequence, under what conditions) each function should be performed (U.S.D.H.E.W., 1974);

3. HOW information from photographs may be of benefit in decision making about disasters and may be incorporated into existing disaster plans; and

4. WHAT baseline or predisaster information from aerial photos and other sources would facilitate decision making.

This document does not address issues and problems related to long-term hazard-reduction and disaster preparedness measures in the predisaster period. While the importance of these measures for mitigating the effects of disasters on communities is not discounted, the focus here is on the immediate postdisaster relief period. Likewise, activities in the rehabilitation period are not the subject of this guide. Aerial photographs would undoubtedly prove useful, however, both to planning long-term hazard reduction measures and to rehabilitation activities. For example, predisaster photographs could be used for land use planning and management and for identifying vulnerable localities and structures. Postdisaster photos are being used in many instances by federal agencies to assist in the assessment of damage and the recommendation to the President that the area be declared a major disaster or emergency.

This guide is directed primarily to decision makers at the local levels of government such as city and county officials. The size of the urban area and the degree of organization of the local response system determines on what level of government the guide could be used. In a large disaster where state and federal agencies are involved, some of the

data gathered may be useful in validating information and making decisions at these levels of government as well.

We are assuming that disaster relief managers know how to perform the functions described, who is responsible for carrying out each function, what additional resources might be needed, how to obtain these resources, and how to determine when each function is completed. The preceding information is usually detailed in SOPs. Information necessary to consider delivery of disaster relief was identified by defining these specific functions and tasks. It was then possible to determine if aerial photography could be used as one source of information.

This guide, then, may be unique in two respects: (1) it identifies the decisions and outlines the general functions and tasks needed to provide effective and efficient relief in the area of public health. We have not found these decisions clearly outlined elsewhere in a functional framework. The decisions, functions and tasks have been specified in diagrammatic form. The diagrams will be useful both to experienced disaster personnel and to those who have no previous experience; (2) it suggests a systematic application of a remote sensing technology for helping to solve certain problems of disaster management. It is not expected that these techniques will replace completely current methods of data gathering; rather it is believed that the more effective convergence of information from all sources will improve the delivery of disaster relief. Aerial photography with interpretation is the primary method emphasized in this guide. Detailed consideration has not been given to other systems such as videotape although their potential usefulness to disaster relief management has not been ruled out.

Disaster relief management and public health are linked in that both are concerned with the interaction of physical, social, and economic factors which aim towards restoring and maintaining a healthy environment. Disasters often interrupt community systems including those necessary to maintain the public health. It is necessary not only to reestablish all the interrupted systems on which the protection of community health relies, but also to manage the potential and actual public health problems during the period of reestablishment. The activities involved in doing this may seem from one perspective to have no relation to health, but from another perspective they are the underpinnings on which the health of a community depends.

Chapter 2

DECISION MAKING IN THE IMMEDIATE POSTDISASTER RELIEF PERIOD

As was emphasized in the first chapter, accurate information is the most critical need in time of disaster. Without accurate and timely information, decisions cannot be made nor priorities established. This need for information exists in the predisaster period of warning and threat and during the disaster, but it becomes most acute in the immediate postdisaster period.

Another need, which may seem less obvious or is assumed already to be taken care of, is a list of the major decisions and questions which need to be made or answered in order to begin restoring the community to predisaster status. In order to provide a framework for managing public health relief activities in the immediate postdisaster period, flow diagrams were constructed of the major questions and the information needed to answer them within each of six general areas of public health concern (Figures 1-6). Community health, as discussed in Chapter 1, relies on the smooth functioning of certain service systems including: medical services, water, liquid waste disposal, shelter, food, and transportation. Many of the tasks on the diagrams may be detailed in local community disaster plans. For example, vector control is included under medical services as one input for estimating the number of potentially ill. An SOP could be written or a flow diagram made for this task alone.

These diagrams are linear, that is, various tasks are ordered sequentially according to priorities. However, relief activities may overlap or they may go on concurrently. In disasters such as hurricanes some

activities (usually those related to preventing or minimizing the effects of the disaster) begin in the warning or threat period. The starting point for each of the diagrams is either during the warning or threat period or immediately postdisaster. Some tasks on a single diagram not only may but should go on simultaneously. For example, repair of the water facilities may go on concurrently with distribution of water even though they are listed sequentially on the diagram. Another point which needs to be made in relation to the diagrams is that they list only the major questions and answers for each area. Questions may be elaborated on or changed to fit the specific needs of the local situation and the type of disaster common to that geographical area.

The questions and answers necessary for decision making in each area are identified by a diamond symbol on the figures. Information needed to answer these questions is enclosed by rectangles. Alternative ways of acquiring some of this information is circled. Parallelograms denote action which must be taken to solve a problem. Double rectangles and parallelograms indicate those information needs and those actions which would be helped by data from aerial photographs.

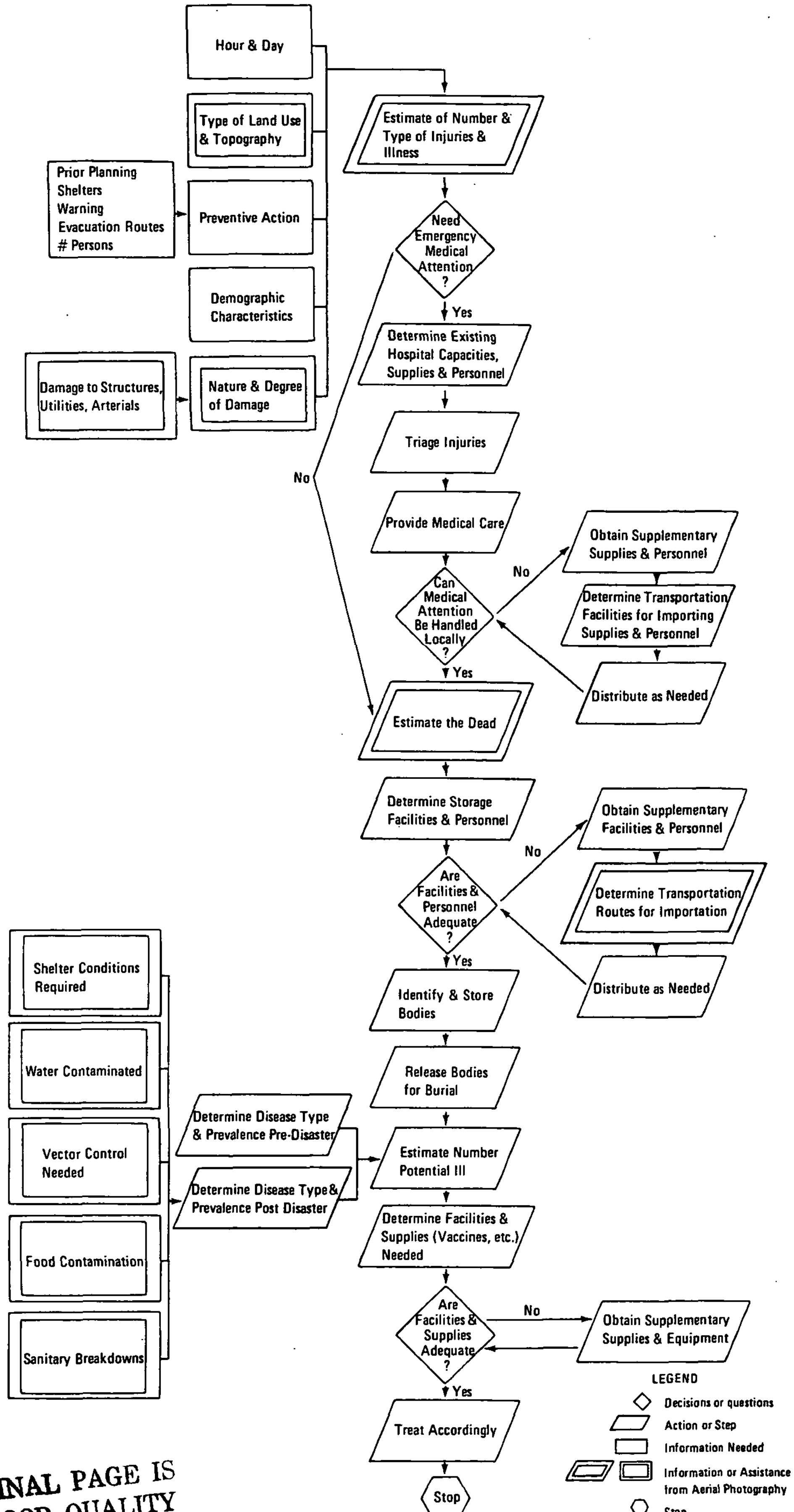
MEDICAL SERVICES

There are two important sub-areas within this function: medical care and health services. Medical care is concerned primarily with personal health care and consists of the activities and services delivered in hospitals, emergency rooms, and trauma centers. When disasters occur, many of the tasks related to medical care do not differ substantially from everyday activities, but they are carried out on an augmented basis and priorities are reordered. For example, more personnel may be required to be on duty to handle the increased number of injuries and cases of illness. Activities in the area of health services, on the other hand, relate primarily to maintenance of the physical environment. In the post-disaster situation, tasks in this area may change qualitatively as well as quantitatively. For example, not only will water sources and food-supplying establishments require continued checking, but vector control will need to be initiated to prevent the inception and spread of epidemics. Health services tasks relate for the most part to preventing the development of disease. The success of health services operations is measured by what does not occur. In the area of medical care efficient management of injuries and illness that have occurred is one standard for success.

Nature and severity of the disaster, hour and day, warning, evacuation and other preventive action are necessary inputs to determine if medical care is needed and, if it is, to estimate the extent and possibly the nature of injuries and deaths (Figure 1). For example, if the disaster occurred at night, damage to business districts of an area would not be as important a consideration as if the disaster had occurred during working hours

Figure 1

MEDICAL SERVICES



thereby increasing the number of persons at risk in the affected area. Although property damage would be comparable, need for personal medical services would be different. An accurate overall assessment of population and area size affected by the disaster can be made using aerial photography. Photography at a scale of 1:18,000 or smaller may be preferred for identifying the extent of the damage since this scale gives an overview of an area (Photograph 2). The photo interpreter can identify the affected area employing map grid squares. Total population and acres (or square miles, etc.) of affected area can be estimated. The specific areas requiring relief activities can be relayed to all mapholders by using grid squares for location identification. (See Chapter 3.)

There appears to be no systematized reporting or recording of injuries following natural disasters. The organization or group that runs the ambulance service is in the best position to know numbers and types of injuries. In most cities ambulance service is privately owned and operated, but in some cities, such as Houston, Texas, it is run by a city agency such as the Fire Department. An unofficial estimate of illnesses and injuries is made by the Red Cross after checking with hospitals, coroners, and other organized medical personnel involved in disaster relief, but initial estimates usually are not accurate. An initial estimate of areas of potentially most severe, medium severe and least severe injury levels might be made from aerial photographs based on degree and patterns of damage. Census or other information on the average occupance per dwelling unit would increase the accuracy of initial estimates.

Responsibility for treatment of injury and illness following natural disasters commonly belongs to the local medical community and sometimes to

the local public health agency. Physicians and other medical personnel in the private sector may or may not be organized to the extent of having prepared SOPs. One consequence of this situation is that there may be an initial surplus of physicians and other medical personnel who volunteer their services followed, after the first few days, by insufficient manpower. With or without SOPs, the effectiveness of this group depends to a large extent on the sophistication of the communications network available to them. Persons in charge of triage* in the field need to communicate with the hospitals in the area in order to be informed of resources available at various institutions and of the existing capacities of these institutions.

Many hospitals have inventories of their supplies and information about their resources and capacities, but there is no central source for obtaining this information for all hospitals in a given geographic area. SOPs might be a useful means of centralizing this information for integrating it into disaster plans. It is generally the responsibility of the local health agency to ascertain resource availability information and to establish resupply requirements. Many supplies needed to treat injuries in disasters are not stockpiled except by trauma centers since they are perishable. However, on the state level, there may be a resource inventory of certain medical supplies needed in emergencies. The SOP for the local health agency could be expanded to include this information. If additional resources are required, aerial photography can be used to

*Triage is the sorting and allocation of treatment to patients, especially battle and disaster victims, according to a system of priorities designed to maximize the number of survivors.

PHOTOGRAPH 2

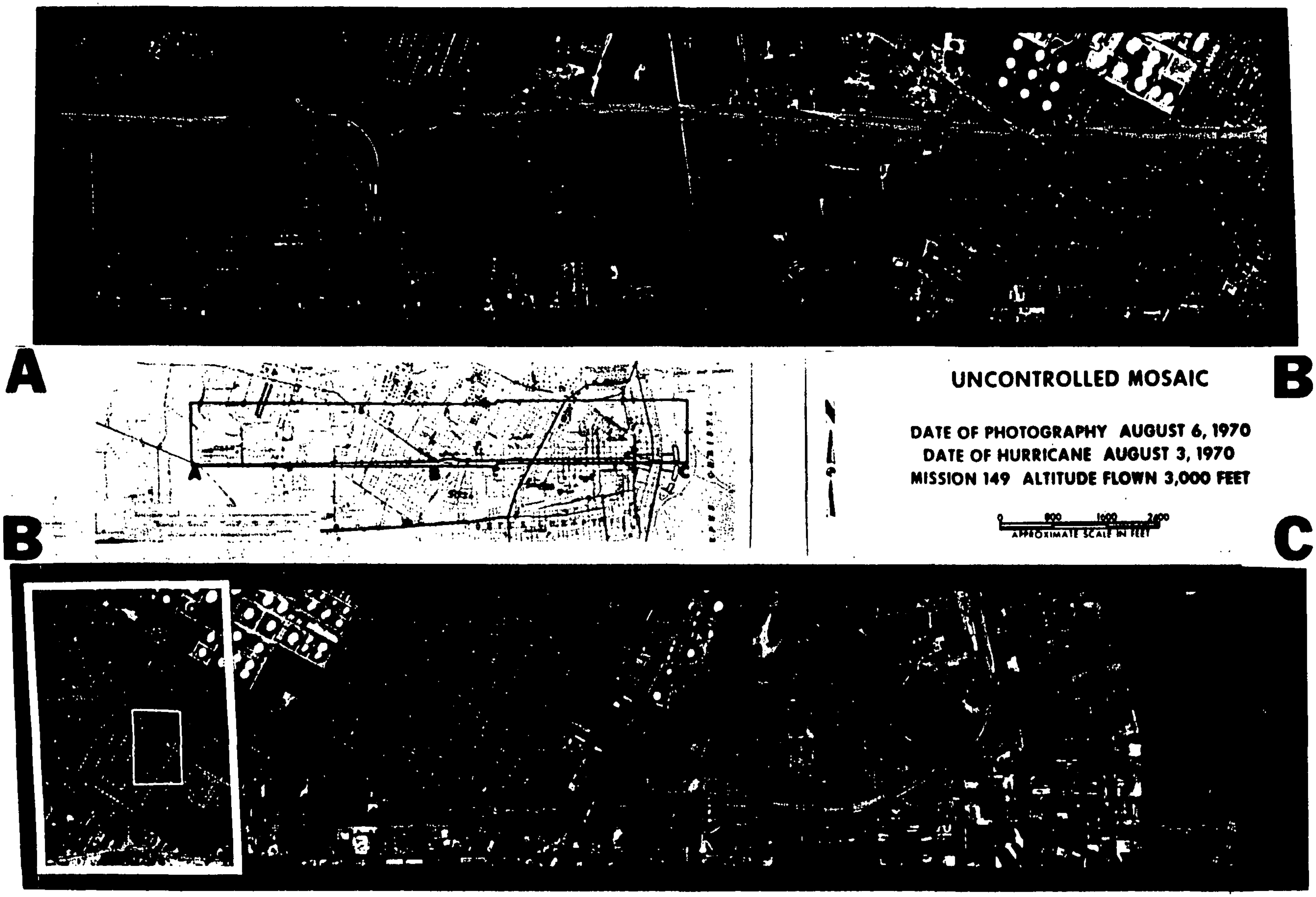
CORPUS CHRISTI, TEXAS, HURRICANE CELIA

Photograph 2 is a color uncontrolled mosaic at a scale of approximately 1:24,000 showing an area in Corpus Christi, Texas which was affected by Hurricane Celia, August 3, 1970. It is a composite or mosaic of a series of 11 photographs and is at the same scale as the accompanying map. The photo coverage can be plotted easily on the map to establish a frame of reference and a location system. In this case topographic maps were used. Alternate reference systems are discussed in Chapter 3. Enlarged photographs may be made of damaged areas which require more detailed analysis (Photographs 3 and 4).

Source: National Aeronautics and Space Administration, Johnson Space Center, Calvin B. Olsen, consulting photo interpreter.

PHOTOGRAPH 2

CORPUS CHRISTI, TEXAS HURRICANE CELIA DAMAGE ASSESSMENT



determine transportation routes for bringing in supplementary supplies, equipment and personnel.

An evaluation of the damage to medical facilities and of their capacity to service the injured must be made. If regular medical facilities are not intact or are inadequate, supplemental facilities must be found. One alternative is first aid stations and field hospitals. Both an assessment of visable damage to medical facilities whose locations have been noted in the predisaster data and locations of alternate treatment centers may be made by aerial photography.

Aerial photography may also be useful in identifying those areas needing vector control measures. Areas of potentially stagnant water which might be breeding habitats for mosquitoes can be found. Large animal carcasses can possibly be seen on low-level photography.

WATER

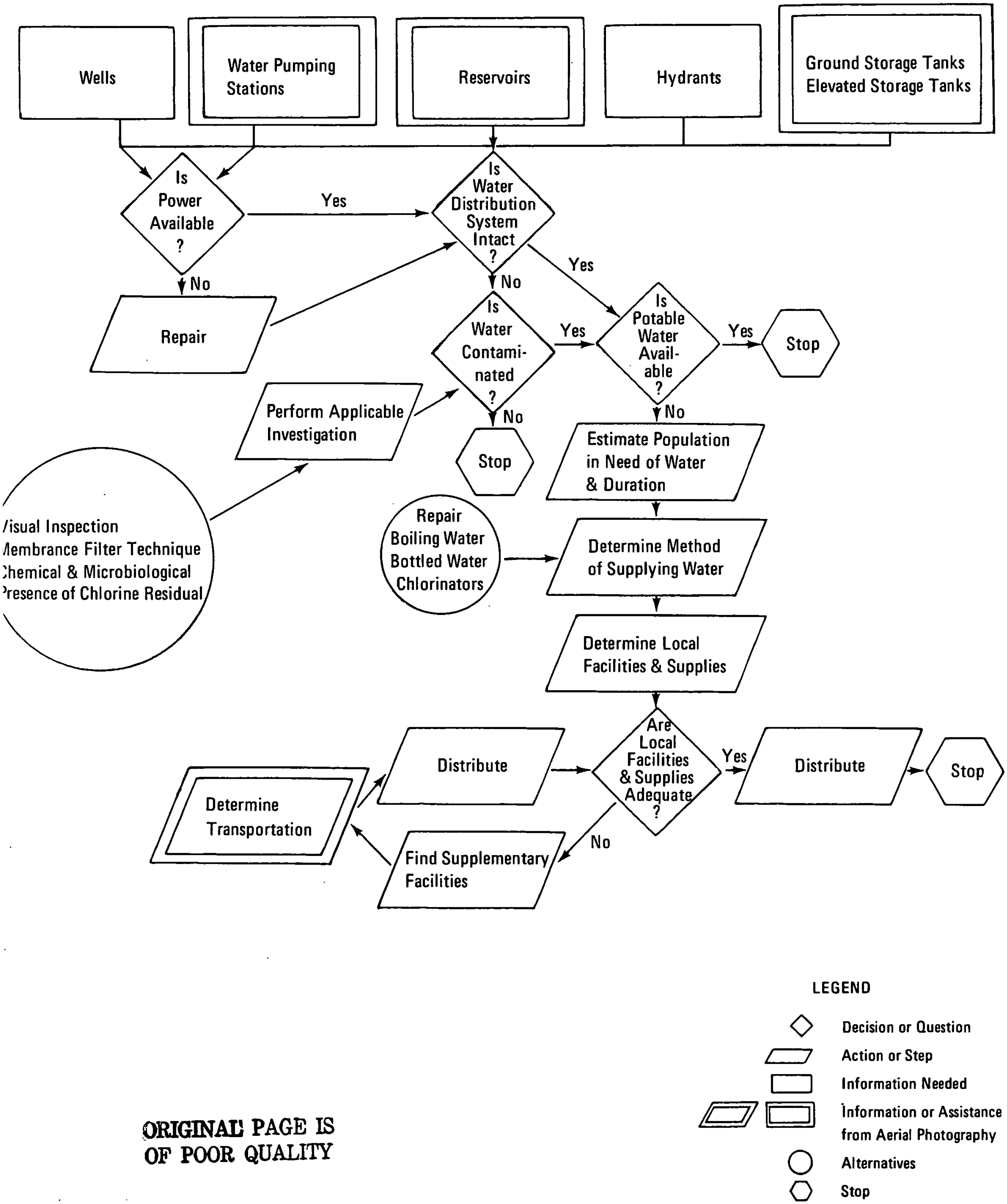
There are five major questions which need to be answered concerning the problem area "water." They include: (1) Is the pumping and distribution system undamaged and operating?; (2) Is power available to operate the pumps?; (3) Is potable water available?; (4) Is the water contaminated?; and (5) Are supplementary water supplies needed? (Figure 2) In time of disaster, information to answer these questions is usually gathered by field survey.

The operation of the pumping and distribution system involves the major elements of the system which include wells, mains, water-pumping stations, ground storage tanks, hydrants, and reservoirs. Water mains are, for the most part, underground and thus are not affected by hurricanes and floods. The exception to this is where mains cross bayous or rivers. Here, wind damage due to tornadoes might result. Underground water mains and other underground systems, however, are particularly vulnerable to rupture from earthquakes. If wells are in low areas, flooding might be a problem. In areas of severe flooding, relief workers might not be able to get into an area to check or repair the system. A preliminary check of the system following a natural disaster takes approximately one day for a city the size of Houston, Texas. The agency responsible for performing these tasks may vary from community to community.

If the water-distribution system is inoperative because of damage to the system or because the source has been contaminated, water must be furnished and distributed. To provide adequate water, the following information is required: (1) an estimate of the population in need of water and the duration of this need, (2) the availability of a method of

Figure 2

WATER



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supplying water, (3) a determination of the status of local facilities and supplies for furnishing water on a short term basis, and (4) a means of distributing water.

In many cities, water and sewer utilities have equipment to monitor information on pressure, mains, storage facilities, and pumping capacity on a continual basis. This monitoring system depends on electric power, and if operational, may provide a rapid source of data in disasters. Consideration must be given to decentralized systems and to looped systems where the damaged parts of the system may be shut off while the undamaged parts continue to operate.

Maps showing utility grids, water and sewerage systems, pipelines, topography, and physical structures will invariably prove useful in assessing damage to the water and sewerage system. Prior information about the locations of water wells and pumping stations, storage tanks, and hydrants will facilitate the photo interpretation process. If these data have not been coded on maps or on predisaster photographs, persons familiar with these systems could assist the photo interpreter in locating these structures on postdisaster photographs. When critical parts of the system have been identified on photographs, degree of damage to surface structures such as wells, pumping stations, reservoirs, elevated storage tanks and hydrants can be determined. Aerial photos can give an overview of the disaster area thus providing a framework in which to set priorities and time estimates for restoring the system.

Once the area in which the water system is not functioning has been identified on a map or photo, an estimate of the population in need of potable water can be made and a method of supplying this need can be

determined. In most instances, an effort will be made to prohibit or limit evacuees from returning to the disaster area until services are restored. Those persons in need of water will most likely be those who did not evacuate plus relief workers. Estimating the population in need of water may be accomplished using aerial photos if information on number of evacuees is available. Photographs may also be used to identify routes for bringing water or supplemental facilities into the disaster area.

LIQUID WASTE DISPOSAL

Three major factors need to be ascertained for this function: (1) Is the sewer system (collection system and treatment plants) working?; (2) Is there a need for supplementary facilities?; and (3) Are these facilities available locally? (Figure 3) This information is usually gathered by field survey. Components of the sewer system which need to be operational are the treatment plants, mains, and pumps. As with water, the operation of the treatment plants and sewer pumps depends foremost on the availability of electric power.

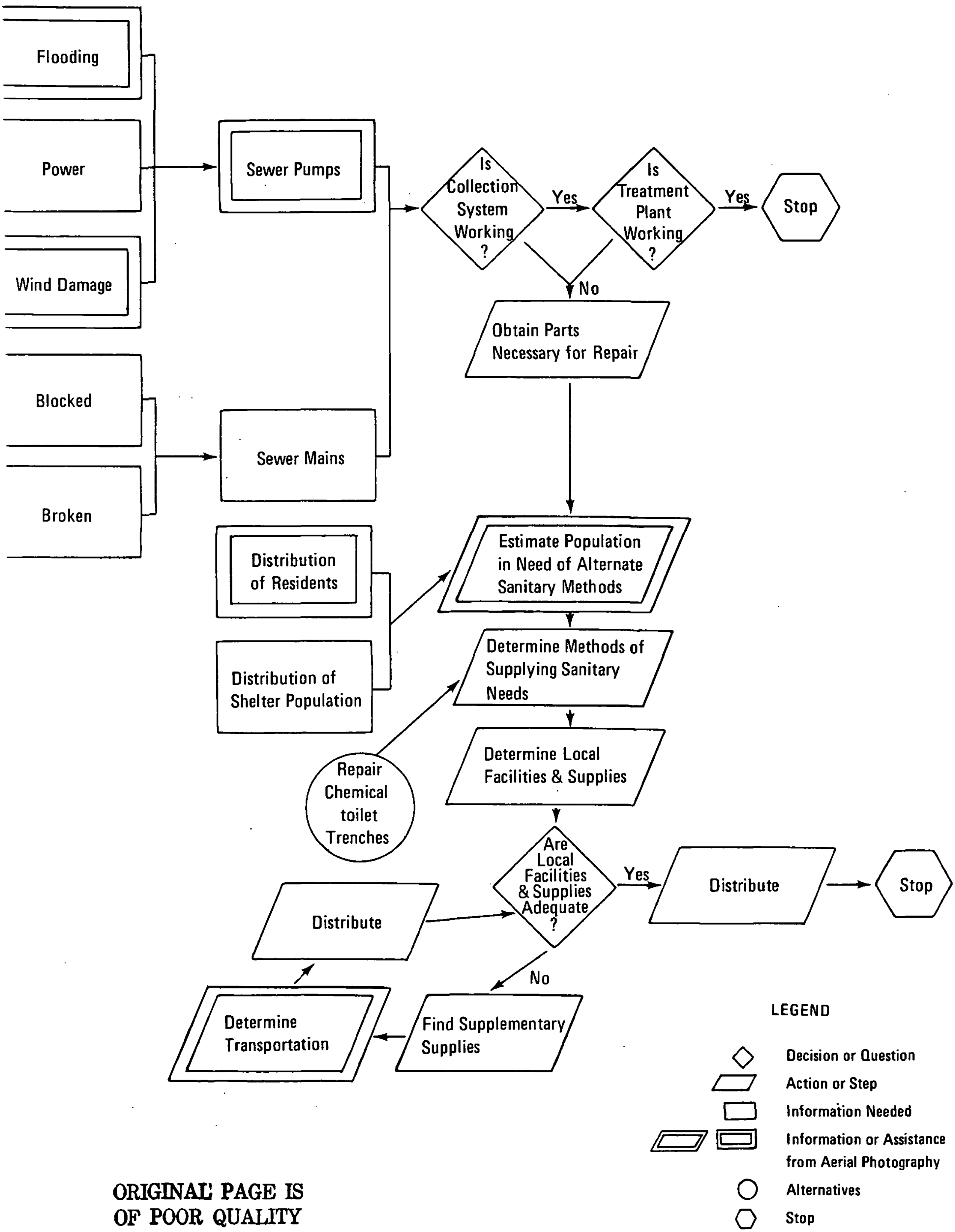
Because sewer mains for the most part are gravity flow, treatment plants are usually located at a low point often near bayous and rivers so that treated waste may be easily discharged. Because of their location, plants may be prone to flooding. Sewer mains may become blocked by trash and flood water. Breaks may occur at trestle crossings where mains cross bayous or rivers although this is rare in hurricanes, floods, and tornadoes since most mains are underground. Pumps and pumping stations may be damaged by wind if they are above ground, while those housed in vaults are more vulnerable to flooding.

In disasters, problems associated with treatment plants and pumps are discovered first while those associated with mains are found last, often by citizens' reports. In Houston after Hurricane Carla it took about three weeks to locate all the problems with the sewer system.

If it becomes necessary to supplement or temporarily replace the regular sewer system, the following information is needed: (1) an estimate of the population in need of alternate sanitary methods, (2) the distribution of the population in need, and (3) a determination of the

Figure 3

LIQUID WASTE DISPOSAL



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local resources and supplies.

As with water, maps of the sewerage system including locations of treatment plants and pumps will be useful adjuncts to damage assessment. With the exception of treatment plants and pumps, the sewerage system is underground and cannot be seen on aerial photographs.

SHELTER

Four major questions need to be answered regarding the problem area "shelter": (1) Are shelters needed?; (2) Are shelter sites accessible?; (3) Are buildings designated as shelters damaged?; and (4) Is their capacity adequate? (Figure 4) The information needed to answer these questions includes: (1) an assessment of the degree of damage to residential areas, (2) an estimate of the population evacuating who suffered major damage to residences, (3) an assessment of the degree of damage to shelters, and (4) information about whether transportation routes to shelters are open (Photographs 3 and 4).

In disasters such as hurricanes and some floods where evacuation is necessary, shelters will begin to open as much as 36 hours prior to the peak of a disaster. In these instances the decision as to whether shelters may be needed is made prior to the impending disaster. Decisions about shelter location may need to be remade, however, following the disaster since some shelters may suffer damage during the disaster. In this case, aerial photography could be used to make decisions about feasible shelter sites. In disasters of sudden onset such as earthquakes and tornadoes where shelters have not been opened before the disaster, the use of aerial photos may expedite the selection of initial shelter locations as well as the other decisions discussed below.

The approximate number of persons requiring shelter and the resources needed can be estimated from aerial photographs based on the geographical extent of the affected area, degree of damage to residential structures, and experience (i.e., usually only about one-third of those persons evacuating an area require government- or Red Cross-provided shelter; others

PHOTOGRAPH 3

CORPUS CHRISTI, TEXAS, HURRICANE CELIA

This photograph is an enlargement of one frame outlined on the mosaic (Photograph 2, frame 5705). It is a vertical color photograph at a scale of 1:6,000. An analysis of the degree of damage to each structure (as opposed to area analysis) is possible at this scale, and outlined structures indicate damage. Four categories of damage which correspond to those used by insurance companies are assigned as follows:

L - Light - Up to 20% damage

M - Moderate - 20-40% damage

H - Heavy - 40-60% damage

D - Destroyed - Over 60% damage.

This level of detail (structure by structure) may not be required in the immediate postdisaster period. Area analysis may provide sufficient estimates for most decisions. For example, obtaining cursory estimates of the population potentially needing shelter may be made from an areal analysis. The number and location of shelters could then be determined although a more detailed analysis of the conditions of specific shelter sites would be required on a structure by structure basis.

The information displayed on this photograph may be summarized by grid location in tabular form or on available maps in the immediate postdisaster period.

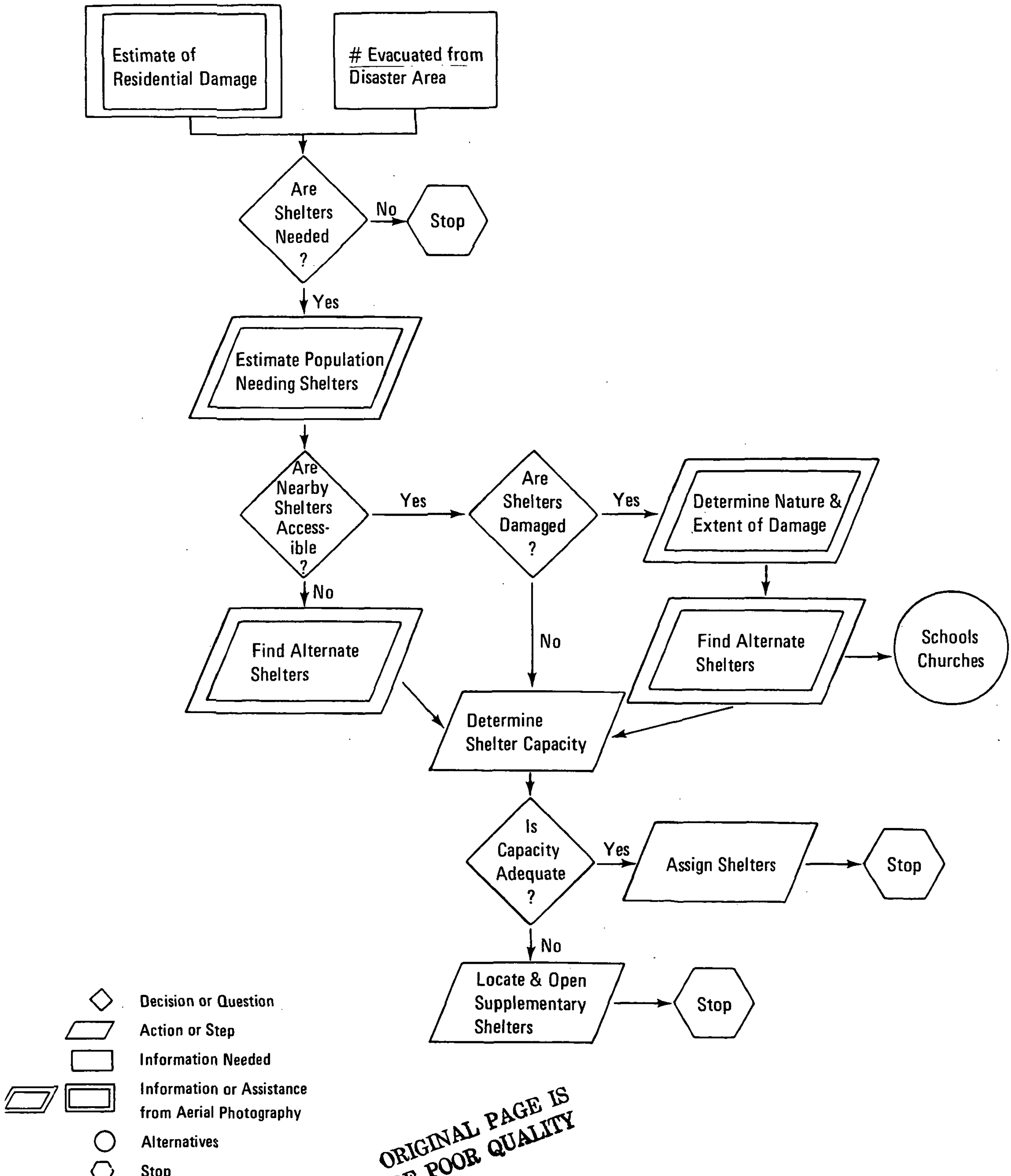
The boxed area is further enlarged as Photograph 4.

Source: National Aeronautics and Space Administration, Johnson Space Center, Calvin B. Olsen, photo interpreter.

PHOTOGRAPH 3
CORPUS CHRISTI, TEXAS HURRICANE CELIA DAMAGE ASSESSMENT
FRAME 5705

Figure 4

SHELTER



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PHOTOGRAPH 4

CORPUS CHRISTI, TEXAS, HURRICANE CELIA

This enlargement of a small section of Corpus Christi, Texas, shows detailed damage sustained by Hurricane Celia. The photo interpreter viewed Photograph 3 on film positive transparencies at an approximate viewing scale of 1:600 by using a viewing stereo-microscope. This detail enabled him to classify damage structure by structure as shown in Photograph 3. This print is at an approximate scale of 1:1200. Photographs at this scale would rarely be needed for immediate postdisaster relief.

Source: National Aeronautics and Space Administration, Johnson Space Center, Calvin B. Olsen, consulting photo interpreter.

PHOTOGRAPH 4
CORPUS CHRISTI, TEXAS HURRICANE CELIA DAMAGE
ENLARGEMENT OF SECTION OF FRAME 5705

go to motels or reside with friends). The kind of land use affected by a disaster will influence the number of people needing temporary housing. For example, if only industrial or commercial areas are damaged, then housing is not likely to be needed.

Shelters provide short-term housing. The undamaged shelters nearest to the stricken area should be chosen for ease of movement. Information about utilities might affect this decision, however. Shelters located where power and water are available would be more appropriate, depending on community resources either to move persons or to provide food and essential services without power and water. Damage to shelters near the stricken area can be assessed quickly on aerial photographs if shelter sites have been identified in the predisaster data. If no damage is apparent, these shelters would be the first to open. If damaged, other shelters need to be identified and routes to them determined. Predesignating potential shelter sites on maps or photo overlays would speed the postdisaster photo interpretation process.

The number of shelters opened will depend on the size of the population affected minus the evacuees. If a widespread area is involved, several shelters may need to open in various locations in the community. Shelter location should be checked against topography to insure that they are accessible in case of high water. Accessibility to shelters as well as feasibility of locations in terms of topographical characteristics can be assessed through aerial photos. Transportation routes affecting shelter location and delivery of supplies can be examined for blockage.

An assessment of the amount of damage to residences and existing community resources will determine if long-term supplemental housing

needs to be made available in the community. Mobile homes may serve this purpose. Aerial photography can provide estimates of the number of severely damaged homes and an assessment of community resources and hence the approximate number of long-term supplemental housing units required by a community. Selection of sites for this semipermanent housing could be made with the aid of aerial photographs.

FOOD

Two major questions need to be answered about the food supply: (1) Is the food supply contaminated?; (2) Is the local food supply sufficient? (Figure 5) The information needed to answer these questions includes: (1) an estimate of the number of people who need to be fed and the duration of this need; and (2) an estimate of the quality and quantity of food locally available for use.

Determination of the suitability of food supplies may be made by chemical and microbiologic means or by visual inspection. It is safest not to use canned goods that have been submerged. Frequently, submerged or bulging canned goods are automatically rejected.

Food-handling establishments such as warehouses, grocery stores and restaurants which have suffered damage should be checked for contaminated goods. The nature of damage to food storage establishments, such as inundation or collapse, may be determined from aerial photographs if their locations have been identified in the baseline data. The extent of structural damage, if any, can also be detailed by this method. If an establishment suffered severe structural damage, food may not be obtainable from it. Water inundation would contaminate fresh or packaged food, and canned food may also be harmed. Refrigerated or frozen food may be rendered inedible in a matter of hours if power is interrupted. Power plants and substations can be identified on photographs and checked for damage and inundation.

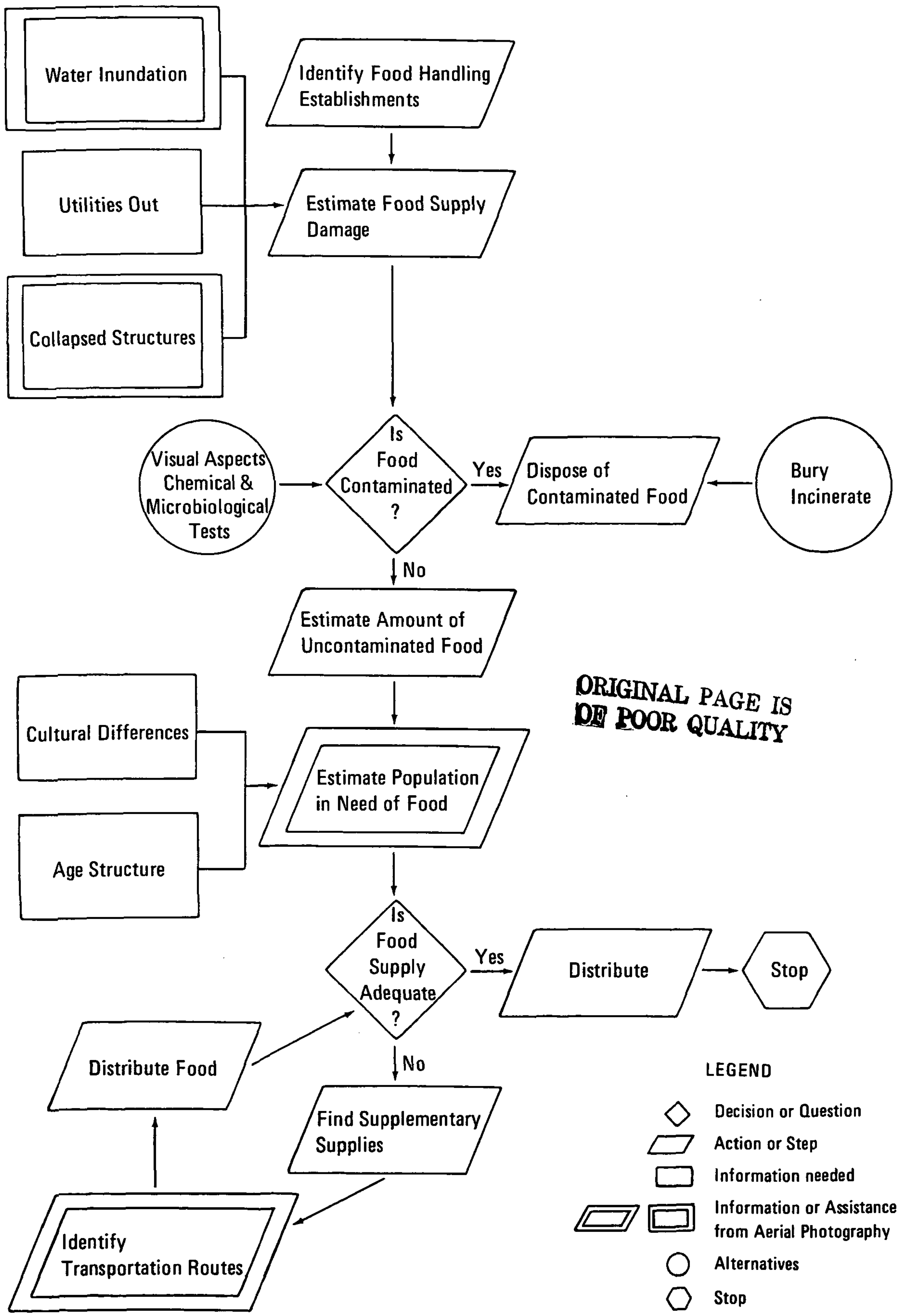
The supply of uncontaminated food must be assessed in relation to the demands upon it. The number of persons and length of time constitute the drains on the food supply. An estimate of persons can be made from

the sheltered population and from the dwelling units without power but sheltering persons. Special food requirements can be estimated by population age structure and by cultural groups affected. For example, infants require different food than adults.

Aerial photography may be used for identifying open routes into the disaster area and for locating food distribution centers. Map or photo overlays may be made of transportation routes and shelter sites, hospitals, and populated areas in need of food to make the distribution process more efficient.

Figure 5

FOOD



TRANSPORTATION

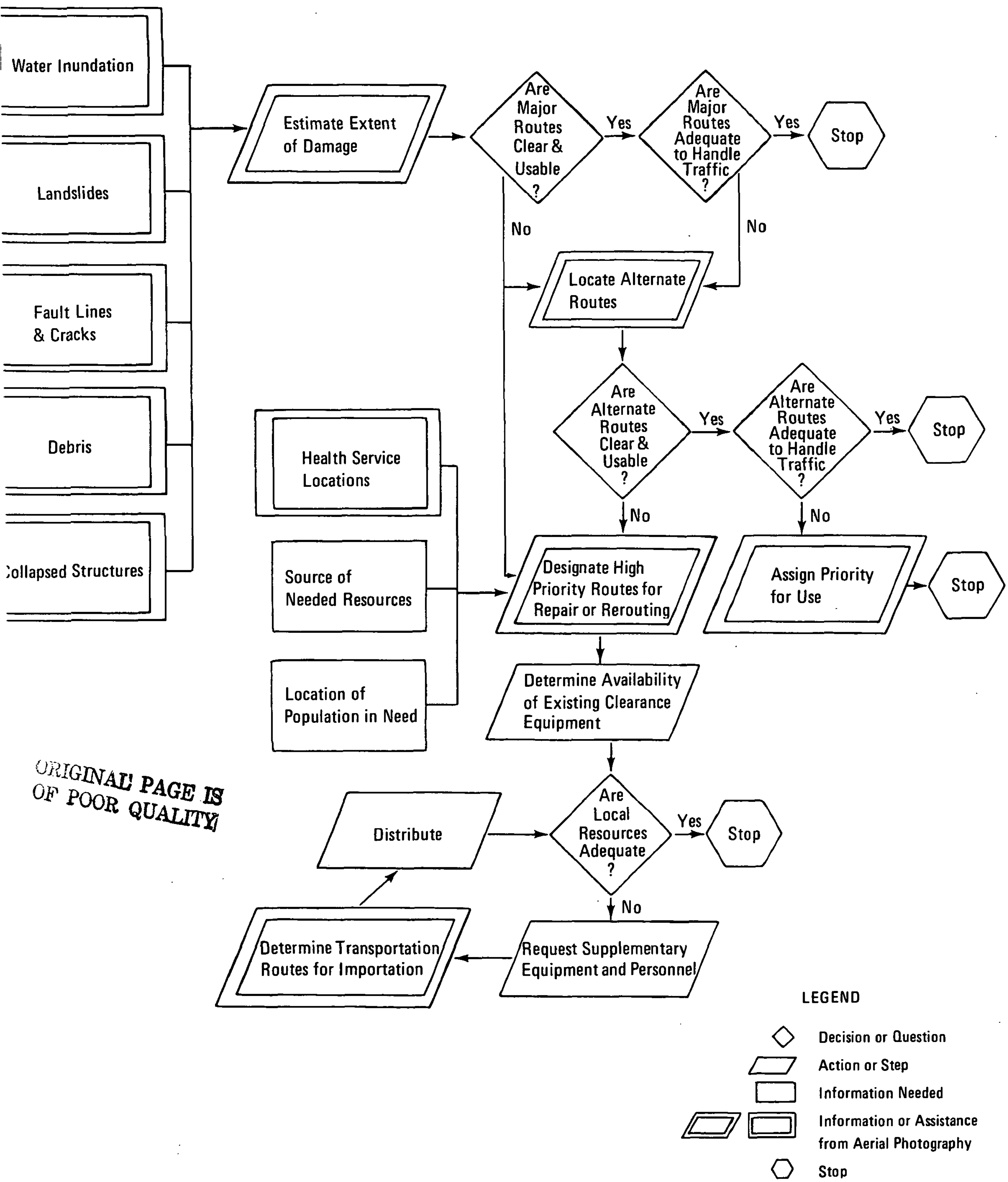
Implementation of some phases of all relief activities involves access to transportation routes. Checking the water and sewer systems, distributing food and water, carrying out rescue operations, providing medical care, and making shelters accessible all depend on open transportation routes and on some means of transportation.

A great deal of preplanning is necessary to execute effectively the tasks outlined on this diagram (Figure 6). Arrangements must be made to obtain vehicles and sufficient fuel and to perform maintenance operations. In addition, vehicles must be allocated for various tasks such as evacuating people prior to the disaster when necessary, moving matériel (clothing, food, medical supplies) within the disaster area, and debris clearance. Evacuation routes may be predetermined and revised if necessary.

Postdisaster, there is an immediate need to determine the condition of major transportation routes and whether or not they are open. Decisions about priorities for clearance or designation of alternate routes must be made quickly. Aerial photography is a very efficient way of obtaining an overview of the situation. It can be used to designate primary and alternate routes into the area and to set priorities and allocate resources for road clearance. (Photographs 1 and 2 are at scales suitable for accomplishing these tasks.) Type of damage to or blockage of various roads can be determined from aerial photos and thus the kind of equipment needed to repair or to clear them can be selected. (Damage to roads can be seen on photographs at the scale of Photograph 3.) The condition of bridges, railroads, terminals, runways, overpasses, and tunnels can also be assessed using photographs. This information would facilitate the process of

Figure 6

TRANSPORTATION



bringing relief workers and supplies into the disaster area. Checkpoints could be established to control the flow of visitors into the area. Surveying the usable routes would be expedited if predisaster data such as maps of the transportation system and essential points were available.

Summary

Many postdisaster actions and decisions could be resolved more quickly if information about the predisaster condition of an area were available. The degree of disruption which a disaster causes to a community will be largely determined by the degree to which the community has prepared for a disaster (Fritz, 1961). Preparation may be in the form of institutional mechanisms of warning and relief such as organizational plans (SOPs) for dealing with the disaster before and after it strikes or informal protective and ameliorative methods used by citizens to cope with the destructive effects of the disaster (Fritz, 1961). Research on disasters has pointed out the difficulty of motivating individual citizens to prepare for disasters especially where the threat of disaster is infrequent or uncertain since these preparations must compete with day-to-day concerns and activities. Thus, the most realistic hope for developing preparedness programs is on the community, state or national level. Predisaster data which would enable community agencies to accelerate the relief process is suggested in the following chapter.

Aerial photography can provide much of the information that disaster managers use to make decisions about relief needs. Table 1 summarizes the visible structures and items that can be identified on photographs. In addition to damage assessment, aerial photography may provide a means of maintaining a central overview of the disaster area which would enable disaster managers to coordinate their activities so as to avoid conflicting or duplicating actions.

TABLE 1

IDENTIFIABLE ITEMS ON AERIAL PHOTOGRAPHS

<u>Type of Facility</u>

1. <u>Structural Damage</u>

Community facilities
- Hospitals and medical
- Schools
- Churches
- Fire stations
- Police stations
- Developed recreational areas
- Civic buildings
- Buildings designated as shelters

Residential
- Single family
- Mobile homes (Trailers)
- Multi-family 1-3 story
- Multi-family - over 3 story

Commercial
- Office
  - highrise
  - other
- Retail outlets
- Motels and hotels

Industrial
- Large manufacturing
- Light industrial
- Wholesale and warehouse
- Storage tanks

Agriculture
- Farming
- Forage

2. <u>Damage to Transportation Routes</u>

Streets
- Obstructed
  - trees/poles
  - structural debris
- Road washout
- Disrupted road surface

Collapsed bridges

Collapsed elevated roadways and subways

Disrupted railroad lines

Airports
- Structural damage
- Damage to runways

(TABLE 1 continued)

Harbors
Ports

3. <u>Damage to Utilities</u>

Broken water mains
Contaminated reservoirs or wells*
Damage to pumping stations
Broken sewer lines
Damaged pumps
Damage to treatment plant
Power plant damage (atomic, regular)
Transformer stations
Downed power/phone lines

4. <u>Areas of Inundation</u>

5. <u>Occurrence of ponded water areas (a potential health hazard)</u>

6. <u>Accumulated rubble and brush</u>

7. <u>Fire damage</u>

8. <u>Safe or shelter areas</u>

*Visual aspects of the water such as the presence of debris and soil may indicate pollution.

Chapter 3

BASELINE DATA FOR PREDISASTER PLANNING

An important step in the process of analyzing the effects of a natural disaster is the comparison of the postdisaster situation with the predisaster status of the area. The collection and assimilation of information about the predisaster area will ensure more efficient and effective organization of relief efforts. Knowledge of how specific systems operate and of what they consist when they are functioning properly will facilitate quicker identification and amelioration of postdisaster public health problems. This chapter suggests guidelines for accumulating data that would be useful in the immediate pre- and postdisaster period. It is not intended as a substitute for an SOP. Much of the predisaster data will also facilitate the major long-term goal of postdisaster reconstruction which is to restore the community to predisaster status.

Baseline information about local systems should be compiled beforehand on maps or photo overlays by the departments concerned so it is readily available for use during and following a disaster (Photograph 5). For clarity, each map or overlay should depict locations of only one theme or resource such as traffic arteries, power lines, or gas mains where features may be in close proximity and would be confused if placed on the same map.

Baseline information useful in public health concerns includes basic demographic, land use, and topographical features of the disaster site. This information may be in map or interpreted photographic form such as photo overlays along with tables of data. The data needed are revealed by the flowcharts of postdisaster functional activities (Chapter 2,

PHOTOGRAPH 5

SAN FERNANDO, CALIFORNIA EARTHQUAKE

This black and white vertical photograph is at a scale of approximately 1:10,000 and was taken following the earthquake which struck the San Fernando Valley, California, February, 1971. Apart from the ruptured dam, this area sustained little visible damage. The Van Norman Dam was dangerously cracked and the water had to be drained from the reservoir to prevent potential flooding of a densely built-up area below the dam. Had the dam burst, low-lying areas would have been inundated.

This photograph and overlay illustrate some information obtainable from aerial photography for predisaster planning. Land use information and major thoroughfares are outlines on the overlay. Home counts were made for one area on the photograph. A contour map showing elevations would permit an assessment of the potential effects of the dam's rupture. With predisaster information available,a more accurate assessment of damage to important resources and facilities can be made postdisaster. For example, following the Managua, Nicaragua earthquake certain sections of the city were so completely destroyed that it was impossible to determine type of structure on postdisaster photography alone.

Source: National Aeronautics and Space Administration, Johnson Space Center, Calvin B. Olsen, photo interpreter.

PHOTOGRAPH 5

SAN FERNANDO, CALIFORNIA EARTHQUAKE

Figures 1-6). For example, to determine needed medical services, predisaster land uses and demographic characteristics of the affected area must be known so that the human effects of the disaster can be more accurately assessed. Crucial sites pertaining to the various functions should also be mapped.

Not only should duplicate maps be available but they should have a common location system for every user. A grid overlay on each map with the grid squares numbered for location reference is recommended. When a smaller area needs to be detailed each grid can be further divided into smaller grid squares. Base maps with an existing grid system will probably have wide distribution before the disaster so that distribution of a special purpose disaster map would not be necessary. For example, U.S.G.S. topographic sheets utilize latitude and longitude as a location reference system and these are readily available. Local communities may also have detailed maps for special purposes. An index map at a small scale typically identifies large scale maps by a grid location system (Figures 7 and 8).

A permanent and current set of data for key persons for each grid square would be optimum. This data set would include population, structure, and land characteristics. Examples of such data are number of children, total population, and institutionalized persons; numbers of dwelling units, day-time occupied structures, emergency public shelters; lowest and highest elevations, floodplains, levees and other ridges or high ground.

Networks such as water and sewer pipes, and streets and highways are not adaptable to tabular form; therefore, maps or photo overlays of these

FIGURE 7

PORTION OF INDEX TO CITY SURVEY MARKERS AND MAP SHEETS

A series of maps with location identification based on a grid system is recommended for locating information needed in disaster relief management. One example of an available map series is that for Houston, Texas (partially completed 1976). It is the product of a comprehensive survey monumentation and mapping program. The four index maps (1" = 3000') display the grid location system. Four sections of each numbered rectangle are lettered. Each of these are further subdivided into four parts. Each numbered rectangle, therefore, contains an A, B, C, and D series, each with 1-4 subparts. Each of these sixteen smaller rectangles is mapped at a scale of 1" = 100' (Figure 8).

Source: City of Houston, Texas, Comprehensive Survey Monumentation and Mapping Program, Sheet I, Index to Survey Markers and Map Sheets, June, 1975.

FIGURE 7
PORTION OF INDEX TO CITY SURVEY MARKERS AND MAP SHEETS

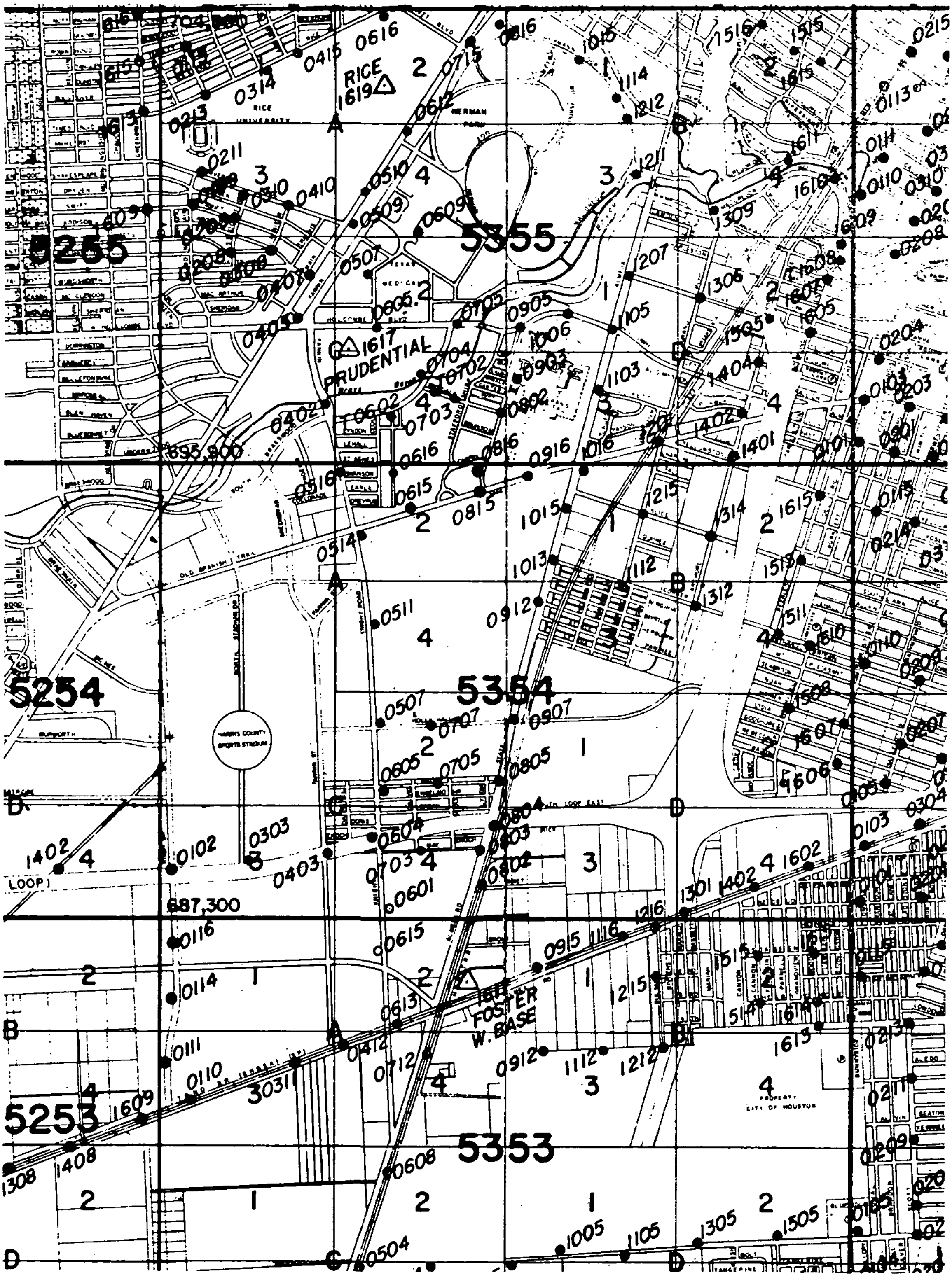


FIGURE 8

SECTION OF MAP SHEET 5355-A-1, HOUSTON, TEXAS

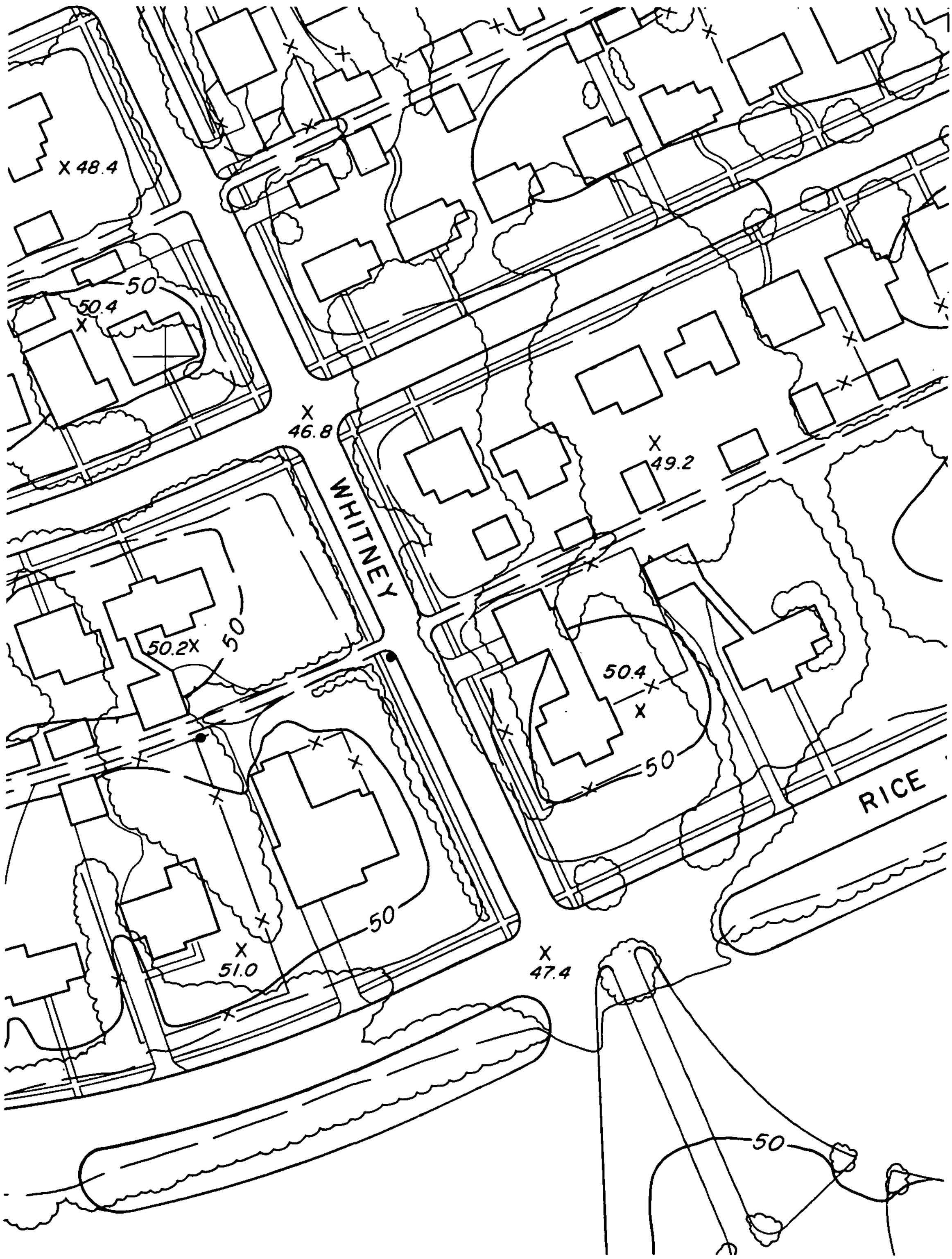
A portion of map sheet 5355-A-1 at the scale of 1" = 100' has been reproduced here. At this scale a great amount of detail may be shown. Streets, structures, sidewalks, trees and shrubbery, as well as elevation contours are depicted. These were compiled from aerial photographs and are an excellent source of predisaster information. Forms for recording data by grid cell appear in Chapter 3.

Disaster data should be compiled on the smallest areal unit. Information for any area could then be summarized by combining the smallest grid sections.

Less detailed and smaller scale maps such as the U.S.G.S. topographic sheets would serve similar purposes, i.e., supply house counts, identify streets, etc. Smaller divisions can be made by dividing the maps into minutes and seconds of degrees of latitude.

Source: City of Houston, Texas, Comprehensive Survey Monumentation and Mapping Program, Sheet 5355-A-1, 1967 Survey.

FIGURE 8
SECTION OF MAP SHEET 5355-A-1, HOUSTON, TEXAS



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systems, overlaid with grid squares, should be available to key persons in the information center. A topical series of maps should also include hospital and emergency room locations, public shelters, schools, and water pumping stations. Local disaster relief managers may determine other crucial sites or critical points within the various systems in their communities for placement on maps.

Wherever possible, steps should be taken in advance of the disaster to protect critical points from damage or destruction. Highly vulnerable areas such as those that may flood or are along fault lines may also be depicted on maps. The baseline information which pertains to more than one function is discussed below under the headings Land Use, Population, and Topography and is summarized in Table 2. Data specific to each of the six public health concerns are suggested in tables following a discussion of the various functions.

Not only should predisaster planning take into account the physical aspects of the vital systems subject to damage, planning must also establish the personnel requirements and assignments necessitated by the disaster. Arranging work schedules to insure sufficient manpower in days following the disaster is an important requirement. Another consideration for the disaster relief manager on the municipal level is to plan for the shelter and care of families of public employees who should be available to respond to the disaster. Experience suggests and research supports that employees' first concern is for their families and that role conflicts may develop if families are not cared for, thus further delaying the relief process.

GRID SQUARE #________________

Table 2*

LAND USE, POPULATION, AND TOPOGRAPHICAL DATA SHEET

Land Use	# Units	Population	
Residential			
Single	______	______	
Multiple	______	______	
Mobile homes	______	______	
Live-in institutions	______	______	
Hotels/Motels	______	______	
Community facilities (mapped)			
Schools	______	______	(Enrollment & Staff)
Fire stations	______	______	(Trucks & Staff)
Transportation			
Heliports			
Streets			

	Employment Each Shift		
Industrial			
(List by industrial subdivision, company name or other local identifier)	A.M.	P.M.	Night
	_____	_____	_____
	_____	_____	_____

Commercial	Daytime Population	Night
Retail	______	_____
Office	______	_____
Open Space		
Parks		
Other		
Other Land uses		

Population	# Dwelling Units	Population
Total population		______
Ethnic group population		______
Ages		
Adult (18-64 & over 65)		______
Children		______
Institutionalized		______

Topography (Mapped)

Elevations

High____________feet

Low____________feet

Landforms

Floodplains

Lakes

Other

Topical maps: See Tables 4-6-9

*The content of Tables 2-9 was validated through interviews with knowledgeables in the various management areas as well as through a literature review. (See especially Department of Defense, 1967.)

Land use

Land use information may be broken down into several categories such as Residential, Community Facilities, Industrial, Commercial, Open Space and Other. The number of residential units gives an indication of the population if the number of people has not been determined by another method such as the Census. Important considerations may be age and quality of structures. Past experiences in the community or in similar communities will suggest the most important variables such as age or construction material around which to organize baseline data. For example, mobile homes are particularly susceptible to wind damage and should be designated separately from other kinds of dwellings.

Community facilities such as hospitals, fire stations, schools, etc. are usually located on small parcels and are scattered throughout the community. Locations of crucial sites, important resources and facilities should be depicted on overlays of predisaster aerial photographs or on base maps since these resources can be utilized in disaster situations (Photograph 5).

Industrial land uses should be identified and noted if they present special situations in terms of risk or critical resource (dairies, food, drug plant). For example, chemicals may require special fire-fighting equipment. Strong winds may topple towers or damage storage tanks thereby creating a secondary hazard. Each community may wish to modify the land use categories to reflect its own needs. Office space may be negligible in some communities, for example.

Population

Total population per grid square represents the potential population-

at-risk in disasters of sudden onset such as earthquakes and tornadoes. In disasters such as hurricanes the number of evacuees must be subtracted from the population base. Population data are needed as a base from which to estimate the number of injured and the number of survivors who may need some form of medical or health service as well as housing, food, and water. Certain groups of the population may need special provisions. Ethnic or religious groups with differing beliefs about medical services or food may be significant in number and should be noted in the baseline data. Other population classes such as age groups may be important.

Illness and injury unrelated to the disaster as well as cases from the disaster and from crowded shelter conditions must be treated. Pre-disaster disease information would be valuable although this may change rapidly. Community disease patterns tend to be widespread. If more stable community health problems are known, sheltering persons with these problems could be anticipated and needed supplies could be arranged early. School principals may be a current source of this baseline data among school age children.

Topography

A topographic map or an aerial photograph with elevations and important landforms would be useful in planning evacuations or movements to higher ground. Delineated floodplains are necessary to determine affected population, impassable roads and isolated community facilities at designated flood levels. A series of maps showing inundated areas at different flood levels can help determine what actions are no longer possible as flood waters rise. For example, evacuation of Galveston Island on the Texas Gulf Coast by land routes becomes impossible after waves reach a

certain height; after flood waters surround crucial sites such as hospitals, emergency vehicles will need to find alternate destinations.

Data Sources

Much of the baseline information already exists in various agency files but has not been compiled for use in disaster relief. Varied information such as data on land use and transportation can be acquired from predisaster aerial photography. Planning commissions are another potential source of land use and transportation information. City departments will have water and sewerage system maps. Other data sources are Forestry Department, Corps of Engineers district office, U.S. Department of Interior, NASA, or military organizations (such as Strategic and Tactical Air Command --SAC and TAC). Table 3 lists potential sources of data on the local area.

The Census of Population is a valuable data source for Standard Metropolitan Statistical Areas (SMSAs). The Census provides information on age groups in communities with greater than 50,000 population. Census block group data break age into three groups for SMSAs: under age 18, 19-61, over age 62. These data would be available only by special survey in communities with fewer than 50,000 population. A Sanborn map series is available for most large cities and gives detailed information on commercial structures for insurance purposes. Some urban places have been surveyed by the American Red Cross. Not all sources are available for every community and not all sources keep the information current. Other local sources can be identified by each community.

Predisaster photography may already exist and may be available for certain areas. One source for such photography is the U.S. Geological Survey. In some cases, this photography may need to be updated depending

Table 3

SOURCES OF PREDISASTER DATA

DATA	SOURCES*
LAND USES	
Residential	Polk Directory Census of Population, Bureau of Census Apartment Association Planning Commission
Schools	School District Planning Commission
Fire stations	Fire Department Planning Commission
Hospitals & other medical facilities	Hospital Association Planning Commission Health Department Medical Association Public Health Service
Power plants	Light and Power Company
Industrial	Industrial Directory Planning Commission
Commercial	Planning Commission Sanborn Map Directory
Open Space	Planning Commission Parks Department
Transportation	State Highway Department Planning Commission
POPULATION	
Total/subgroups	Census
TOPOGRAPHY	
Elevations/landforms	U.S. Geological Survey Topographic Sheets Army Map Service
PREDISASTER PHOTOGRAPHY	U.S. Geological Survey, Map information Office U.S. Department of Agriculture

*At the county or city level private map companies and municipal offices such as those listed here are sources of maps which could be used in the compilation of baseline data.

on date of the photographs and the growth rate of the community.

As mentioned, tables of recommended baseline data follow short descriptions of each of the six systems of public health importance. These tables present the optimum information about each grid square that would prove helpful to disaster relief managers. Again, we wish to emphasize that each community is unique in terms of the hazards to which it is exposed and of the potential disruptions to its systems. The suggested data, then, may need to be expanded or changed to meet the planning needs of individual communities.

MEDICAL SERVICES BASELINE DATA

The normal operation of medical services requires that the major structures such as hospitals be intact and that staff be available to carry out routine procedures. Treatment of injury and illness following a natural disaster can be done more effectively and efficiently if everyday facilities are utilized and personnel, with a few exceptions (e.g., diversion of a few physicians to organize disaster activities such as triage), augment their normal everyday activities. Responsibility for treatment of injury and illness in the community belongs to the local medical community in so far as possible and this remains true during and following a disaster.

A means of transporting the injured to treatment centers and a system for distributing them to appropriate facilities should exist. Efficient dispersement of injured in a disaster depends on (1) a system of communication so that changes in the receiving capability of local hospitals can be monitored,(2) information about the services offered and the resources available to the hospitals, (3) kinds and numbers of injured and ill, and (4) availability of suitable transportation.

Information from the three basic sets of data as well as maps of important resources and facilities make up the recommended baseline information relevant to medical services (Tables 2 and 4). These data provide a means (1) to estimate the type and number of injuries, (2) to assess the adequacy of medical resources, and (3) to delineate routes for transporting the injured to hospitals for treatment. All data should be recorded by grid square as recommended earlier.

Predisaster land use data if sufficiently detailed provide a means of estimating the number and possibly the type of injuries (Table 2). In addition, an estimate of daytime and nighttime employment would help determine the population-at-risk of injury in a disaster of unexpected onset. Commercial and industrial uses are important daytime activity centers and create a large population-at-risk.

Locations of resources and facilities such as hospitals, nursing homes, clinics and medical professional buildings should be depicted on overlays of predisaster aerial photographs or on base maps (Table 4). Each hospital site should be listed separately with information regarding its capacity to handle disaster victims, the services it offers, and its accessibility in terms of proximity to major transportation routes, heliports, or landing strips.

GRID SQUARE #________________

Table 4

MEDICAL SERVICES DATA SHEET

Crucial Sites

Health Supplies & Equipment
- Locations of Producers
- Wholesalers & Warehouses of:
  - Dressings
  - Antibiotics
  - Serums
  - Blood collecting & dispensing supplies
  - Surgical instruments
  - Pharmaceuticals
  - Shock fluids
  - Narcotics

	Employment by Shift		
	A.M.	P.M.	Night
Hospitals			
Current bed capacity	______	______	______
Rated bed capacity	______	______	______
Expanded bed capacity	______	______	______
Average daily census	______	______	______
Doctors	______	______	______
Nurses	______	______	______
Other personnel (composition may be detailed by specialty)	______	______	______
Annual outpatient visits	______	______	______
Power Plants			

Clinics
- Same as for hospitals if inpatient

Nursing Homes
- Same as hospitals

Medical Professional Buildings
- Number of doctors
- Number of other personnel (detail)
- Bed capacity
- Types of equipment
- Types of supplies

WATER BASELINE DATA

For a modern water distribution system to deliver potable water, electric power must be available to operate the pumps, the major components of the system must be undamaged, and water must be uncontaminated. Components of the water system may include wells, mains, water pumping stations, storage tanks, water towers, hydrants, reservoirs, dams, flumes, and treatment plants (Table 5). Maintenance and repair of the pumping and distribution system is the responsibility of the authorized operators of the water system. Control of this function may vary from community to community.

Determinination of the suitability of drinking water sources may be made by chemical and microbiological means. Depending on the source of the water, different treatment methods and degrees of treatment are used. For example, water from deep protected wells may be safe to drink as it comes from the well or may require only slight chlorination. Water from other sources such as lakes may require more complex methods of treatment. Water is routinely checked for contamination throughout the distribution system, at the water plants, and at the source. Collection of water samples for determination of microbiologic contamination and unwanted chemicals is usually done by both the water division or company and the local health agency or department. Responsibility for testing for the potability of water usually rests with the health department. If water sources in the postdisaster period are inadequate due to contamination or to system disruption, population and topographical data (Table 2) may be used to estimate the number in need of water and to identify routes for bringing it into the area.

GRID SQUARE #____________

Table 5

WATER DATA SHEET*

- Crucial sites
  - Sources of water
    - Lakes
    - Rivers
    - Streams
    - Springs
    - Wells
    - Reservoirs
    - Elevated storage tanks
  - Source of power
  - Watertowers
  - Pumping stations
  - Intake towers
  - Treatment plants
  - Filter stations
  - Dams
  - Flumes
  - Hydrants
    - Size of hose connection
  - Mains
    - Diameter
    - Pressure
    - Type of pipe
  - Valves
  - Major repair equipment
  - Bactericidal facilities (Chlorination)
    - Laboratory facilities needed to test water (both chemical and microbiologic)
    - Identify primary and secondary labs

*Other data which do not lend themselves to representation in graphic form but would be useful include: supply flow (gallons daily), supply pumping (gallons daily), distribution storage (gallons), number gallons treated daily, distribution and pumping flow (gallons daily), populations served, number of repair crews for major and minor repairs, inventory of major repair items, and type, capacity, mobility and amount of treatment chemicals.

Wells, water towers, mains, pumping stations, reservoirs, dams, storage tanks, hydrants, and major valve locations are crucial points (Table 5). It is impractical to map hydrants as baseline data because of their large number. Perhaps certain hydrants which are part of the subsystem serving other crucial points (e.g., hospitals, fire departments) could be pinpointed for special attention. Fires pose a secondary hazard in earthquakes and are difficult to control if the water system is not functioning.

As mentioned in the preceding chapter some components of this system may be monitored continuously by electronic equipment. If power is available, this would be a rapid source of data. Another important planning consideration is the decentralization and looping of the system so that disrupted sections may be shut off while other sections continue to operate.

LIQUID WASTE DISPOSAL BASELINE DATA

The operation of the sewer system, like the water system, is predicated on the availability of electric power since power is necessary to operate sewer pumps and treatment plants. Mains are another component of the system, but since they are for the most part gravity flow, electric power may not be important to their operation. Where mains are gravity flow, treatment plants are located at a low point often near bayous, rivers, and oceans to facilitate discharge of waste. Pipe materials are an important consideration since clay tile is friable and may be susceptible to rupture during an earthquake while steel is more durable. Responsibility for maintenance and repair of the sewer system usually rests with the company or department who operates this system.

The locations of treatment plants and sewer pumps are important sites to have pre-marked on maps or other graphics such as photo overlays, engineering drawings or blueprints since these are major parts of the system (Table 6). These sites should be cross-referenced with topographical information (Table 2). Diagrams of sewer main systems will be useful especially in disasters such as earthquakes where ruptures to this part of the system are likely to occur.

GRID SQUARE #____________________

Table 6

LIQUID WASTE DISPOSAL DATA SHEET

Crucial sites

- Collection plants
- Treatment plants
- Sewer pumps
  - Lift stations (visual)
- Sewer mains
  - Pipe material
    - Clay tile
    - Concrete
    - Plastic

SHELTER BASELINE DATA

The residential units of most areas provide shelter for a relatively permanent population. In addition to those living in dwelling units, others reside in nursing homes, dormitories, prisons and other institutions. Persons who are traveling or are between residences may be staying at hotels and motels. Other temporary quarters may be hospitals and jails.

When the normal living system is disrupted, temporary quarters need to be established on a public service basis. Many persons have the resources to obtain substitute shelter for themselves, but some (usually about 1/3 of those seeking shelter) will be helpless without organized relief efforts.

The persons potentially in need of shelter include both the residential and institutional populations. Those residing in specialty quarters may need special provisions such as nurses, guards, or other equipment. Moving these persons to another similar facility might be more efficient than relocating them to a shelter if transportation and alternate facilities exist.

Persons who have been dislodged from dwelling units, hotels and dormitories may be relocated to accessible shelters. Estimates of the numbers that might require shelter should therefore be kept current for the grid square areas. If an entire grid area suffers damage or is inundated, the total population will potentially need shelters. An area may be so badly damaged that estimates could not be made from the debris. In this case, only knowledge of the predisaster situation could give an accurate account of the problem.

Critical information includes both the normal situation and the postdisaster situation. It is the difference between the number of housing units standing predisaster and the number habitable after the disaster which most accurately indicates the damage. Without baseline information, postdisaster data will be less useful.

Potential shelter sites should be known by governmental authorities in advance in case emergency housing is needed. Relocation sites are not announced to the public until staff and supplies have been arranged. Schools and churches are most often designated as shelters since each neighborhood contains at least one such facility and since these structures often can accommodate the sanitary and food needs of many people. These sites need to be noted on the standard maps so selection of appropriate ones (i.e., those undamaged and closest) can be made (Table 7). Other sites, which could be designated as shelters if needed, should also appear on the maps. These may be structures servicing large daytime populations such as office buildings, libraries, college campus buildings, fairgrounds, veterans halls, and armories. Those best suited would have large spaces for sleeping arrangements, multiple restrooms and perhaps kitchen facilities.

Potential secondary effects should be kept in mind. For example, shelters may present additional community health problems because of crowding, disruption of procedures conducive to good personal hygiene, etc. Under these conditions communicable diseases can spread with ease.

The capacities of shelters (Table 7) and the numbers of residential units (Table 2) form part of the baseline data for shelters. The estimated daytime and nighttime populations complete the recommended baseline information (Table 2).

GRID SQUARE #________________

Table 7

SHELTER DATA SHEET

	Water	Sanitary Facilities	Feeding
Potential Shelters (capacity)			
Schools			
Churches			
Hotels and motels			
Other			

FOOD BASELINE DATA

Food handling establishments in a community include retail grocery stores, wholesalers, warehouses, restaurants, schools and institutions. Food supplies are continually being shipped into cities and with total disruption of this system the supply at any one time may last only a few days.

Special subgroups of the population may need special foods. Sources of baby food and other canned goods would be valuable baseline information. Fresh fruit, vegetables, and milk will not be edible after a few days without refrigeration so these items should be consumed early or converted into food forms with a longer shelf life. An estimate of the population needing food and its location can be made from data in Table 2.

Predesignation of major food handling and storage establishments and other food supply sources need to be made on maps (Table 8). Topographical features must be considered (Table 2). Other data required for determining food edibility would include knowledge that the power system was working and that the storage buildings were intact.

GRID SQUARE #____________________

Table 8

FOOD DATA SHEET

Crucial Sites

- Grocery warehouses
  - Number and Square Footage
- Grocery wholesalers
- Grocery stores
- Restaurants
- Power plants
  - Regular
  - Alternate

TRANSPORTATION AND COMMUNICATION BASELINE DATA

Transportation routes and communication lines are of major importance to the proper functioning of a community. Ham radio operators sometimes have proven to be a valuable source of information in disasters. The locations of ham radios may be marked on maps as a potential resource. Citizen band radios are becoming common and may prove useful, as well. These systems allow interaction of persons and may make necessary services accessible.

The conditions and capacity of major transportation routes should be predetermined. A listing of each essential route, bridge, airport and other critical sites should be available (Table 9).

A map of major auto and rail arteries is the best form of recording their location. Airports, heliports, and water routes may also be of local importance. These may be located by symbol or number on transportation map(s) or photo overlays. Route capacity (e.g., number of lanes) can be identified on a map by relative line widths.

Grid Square # ____________

TABLE 9

TRANSPORTATION DATA SHEET

Auto and Bus Routes

Major arterials

Bridges and overpasses

Tunnels

Traffic signals

Overhead power wires

Traffic bottleneck

Road sections subject to flooding

Rail Routes

Tracks (main lines and alternate routes)

Bridges

Tunnels

Causeways

Viaducts

Terminals or stations

Classification yards

Subways

Repair shops

Airports and Heliports

Runways

Terminals

Access

Limitations

TRANSPORTATION DATA SHEET (Continued)

Water

- Location of piers
- Inland waterways
  - Locks
  - Dams

Vehicle Resources

- Distributors of new and used cars
- Number buses (commercial and school)
- Number trucks, vans
- Fuel supplies
  - Locations

Specialized

- Refrigerated vans, ambulances, etc.

<u>Summary</u>

Baseline or predisaster data which would be useful to decision making in the immediate postdisaster period have been suggested for the six areas of public health concern along with guidelines for organizing these data. Many of these data already exist in various agencies, but they may not have been compiled for use in emergency situations. Potential sources of these data have been identified. In order to fully assess the impact of a disaster on an area, information about its predisaster status must be known. Aerial photography is one way of acquiring and recording such data.

CONCLUSION

This guide has suggested a framework within which to plan, organize, and deliver public health relief in the immediate pre- and postdisaster periods. Questions within six areas of public health concern have been outlined along with information needed to make these decisions. Ways to incorporate a new data source--aerial photography--with current information systems have been suggested to help solve the problem of the lack of accurate information and to facilitate decision making in the postdisaster period. Aerial photographic technology which is now available and can be used to provide information for decision making to expedite the delivery of relief has been described. Information acquired through this method is flexible, specific, timely, and applicable in any type of disaster. Immediate implementation of a remote sensing system following natural disasters will be most effective if this system is incorporated into existing plans through predisaster planning. The predisaster data which communities could use to accelerate the relief process have been discussed.

The scope of this guide is limited to public health problems and activities in the immediate pre- and postdisaster periods which can be helped by using information from aerial photographs. It is likely that the data source described here would also prove useful both to long-term hazard-reduction measures in the predisaster period and to postdisaster recovery.

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APPENDIX

APPENDIX

The timely acquisition of remote sensing data is of foremost concern if it is to be used effectively in the disaster relief decision-making process. Disaster relief managers judge the feasibility of data acquisition systems on the speed and accuracy of the response. Consideration must be given in the predisaster period to remote sensing systems that best suit the needs of a given community. Knowledge about the area to be flown, the photographic equipment to be used, aerial survey techniques, and photo interpretation are vital elements in the data collection process.

Remote Sensing Systems

Remote sensing as a field has expanded from aerial photography to include multispectral and infrared photography as well as radar and electromagnetic scanners. At the present time, the most appropriate sensors for disaster relief management are those in the visual range. These include photographic systems using regular color and black and white film as well as color and black and white infrared film and possibly videotape and real time data-link relay (return beam vidicon). Many photographic systems may be mounted in either fixed-wing or helicopter aircraft. Although many remote sensing systems may be theoretically constructed for the particular needs of disaster analysis, the following three types summarize the current potential of this field.

First is a camera system using a standard film to predetermined specifications--the system described in this guide. It is important that the photographs produced are the proper quality and specifications for the

needs and skills of the photo interpreter. Table 1 lists some types of aerial photographs useful for disaster analysis. The film would have to be processed in a laboratory and would become a permanent record of the disaster. The processing laboratory may be located away from the disaster site if the developed film can be flown into the area. The advantages of a camera system (almost all civilian and military aerial photography is of this type) are its availability, multispectral potential, and ease of duplication once the film is in the processing plant. The main disadvantage of the camera system is that the film cannot be reviewed in flight and so poor quality photographs are not discovered until they are received from the processor. Also, filming the disaster using regular black and white or color film should be done between 2 hours after sunrise to 2 hours before sunset (the optimum time is from 10:00 A.M. to 2:00 P.M.). Otherwise, shadows obscure a large part of the land surface and low quality exposures are likely to result.

Second, A KS-72 camera system using Bi-mat film produces in-flight, finished photographs which may be delivered directly to the disaster site. The advantages of this system are ready access to finished transparencies (both positive and negative) and the adaptability of the Bi-mat film apparatus to many existing cameras which may not be using it presently. The disadvantages of the Bi-mat system are its accessibility (how easily may it be obtained for use) and cost (both for installation of the system and for the film it uses).

The third system consists of a silicon diode array vidicon camera mounted in a vertical configuration, two small (3") video monitors, and a video tape recorder (all of which are mounted in the aircraft). Some

TABLE 1

TYPES OF AERIAL PHOTOGRAPHS

Type of Photograph	Description and Uses
Vertical	Provides a straight down view. By overlapping consecutive exposures (60% overlap along the line of flight and about 30% sidelap [minimum] between adjacent flight strips), any overlapping pair of exposures can be viewed three-dimensionally with an optical device known as a stereoscope. Useful for interpreting predisaster land uses and for obtaining an overview of the area postdisaster. May be used for detailed postdisaster damage assessment (stereo preferred).
Oblique/Panoramic	Provides a wide angle, perspective view in areas of level terrain. Generally best employed to show specific features at low altitudes or as supplements to vertical exposures. Not useful in rough or mountainous topography. To provide stereo coverage, a panoramic camera in the vertical mode will provide 60% overlap in the line of flight (60° to either side of vertical for a total swath width of 120°). Useful for detailed postdisaster damage assessment, especially tornado or strong wind damage.
Mosaic	Provides a composite picture which gives the appearance of a single large picture and which is assembled by using only the central nonoverlapping portions of vertical prints. Semi-controlled mosaic is constructed at a relatively constant scale by adjustment to ground survey points. Uncontrolled mosaic lacks adjustment of linear distances. Mosaics are not as useful in mountainous terrain. Mosaics may serve as maps for which overlays can be made for recording predisaster data and for centralizing postdisaster information. Photo interpreters also use mosaics for planning purposes and for indexing photographs.
Comparative	Photographs of the same area taken at approximately the same scale and film angle at different points in time. Useful for updating predisaster data and for monitoring postdisaster reconstruction progress.

advantages of this system are instant review (even by the pilot in the air) and instant playback on the ground over larger video monitors. Because videotape is instantly available for review and playback, rapid decisions about relief needs could be made in light of the scene on the ground. Other advantages are that the system is lightweight, needs no aircraft modification because it is handheld and is not limited by shadows so pictures can be taken as long as there is light. Depending on the system, the cost may be relatively inexpensive. Because technological improvements occur so rapidly in this field, renting a video system would be preferable to purchasing it. The main disadvantage of video tape is that its application to disaster assessment has not been tested although similar systems are used daily by TV news personnel. Other potential disadvantages include the fact that resolution is rather poor, that the photo scale is limited, that the ground-receiver must be within 30 miles of the aircraft in order for there to be reception, and that the photographer must document the location of his films. Videotape would probably be of optimal use in conjunction with some type of aerial photographic system since the degree of resolution may not be adequate for some of the detailed photo interpretation required and the scale may not allow an overview of the area.

Aerial Survey Methodology

Aerial survey methods are extremely important to the determination of specifications for photographs. To implement remote sensing it is preferable to arrange in advance for equipment, aircraft, and personnel. Tables 2 and 3 list some photographic systems and aircraft that have been used to film and fly disasters. Requirements should be set for film types, scale, overlap, etc. as well as for the type(s) of photographs

TABLE 2

PHOTOGRAPHIC ACQUISITION SYSTEMS WHICH HAVE BEEN

USED TO PHOTOGRAPH DISASTERS

Commercial Systems

Sensor	Focal Length	Format
Fairchild CA-8 (vertical)	6"	9 1/2" x 9 1/2"
Wild Heerbrugg RC-8 (vertical)	6"	9" x 9"
Zeiss RMK 30/23 and 15/23 (vertical)	6" or 12"	9" x 9"

Government Systems

KA-51, KA-53, KA-62 (series) (vertical)	6", 12", 3"	5" x 5"
KS-87 (series) (vertical)	3", 6", 12", 18"	5" x 5"
Panoramic	3"	5" x 5"

TABLE 3

AIRCRAFT WHICH MAY BE USED TO PHOTOGRAPH DISASTERS

Type of aircraft	Source	Altitude
U-2	Government	65,000
RB-57	Government	60,000
SR-71	Government	60,000
P-3 Orion	Government	25,000
RF-4C	Military	35,000
RA-5C	Military	35,000
RF-8G	Military	35,000
Mohawk	Military	30,000
Twin Beech mdl. D18	Commercial	18,000
Piper Comanche	Commercial	10,000

C-2

(Table 1). Specifications for aerial photographs should be determined by experience gained from test flights and data analysis.

Essentially, the photographic product is determined by the equipment (aircraft, sensors, etc.) and the standards and specifications previously set (scales, film type, etc.). Atmospheric conditions are also a determinant of when the flight is made, the altitude of the plane, and which areas are photographed first. A balance should be reached between the constraints of equipment and weather, and the need to have data for the agencies responsible for making decisions about relief action.

Large scale vertical and oblique photographs are taken preferably in stereo for photo interpretation. Structural damage is more easily detected with stereo viewing. For some disaster damage assessment, an oblique view is preferable to a vertical view since some damage may not be apparent from a straight down perspective.

It is sometimes advantageous if the base scale or negative scale of the photographs is about the same as available comparison charts and maps. Base photo scale refers to the scale at which the film was taken and is determined by the focal length of the lens and the altitude of the plane. The scale can be adjusted (enlarged or reduced) for viewing purposes (viewing scale) with proper equipment and film type. Some black and white film may be magnified as much as 15 times without loss of resolution (detail of the images). Good color film can be enlarged approximately 8 times without loss of resolution. A focal length of 6" at an altitude of 18,000' will produce film at a scale of 1:36,000 which can be enlarged at least 8 times to 1:4,500 with minimal loss of resolution. At 18,000' altitude with a 6" lens cone one exposure will cover an area of about 25

square miles with a 9.5" x 9.5" camera format. At 1500' altitude with a 6" lens cone, the coverage would be approximately 2.5 square miles. For some damage assessment a viewing scale of approximately 1:600 may be needed. A base scale of 1:6000 (6" lens at 3,000' altitude) would result in this viewing scale if the film were capable of being enlarged 10 times. Table 4 lists the approximate scale for various types of disaster damage assessment.

TABLE 4

SCALES OF PHOTOGRAPHY AND THEIR USES IN DISASTER ASSESSMENT

1:3000 - 1:6000	Most often used for detailed damage analysis to structures and utilities; identification of most types of structures; animal carcusses can be seen at these scales.
1:10,000 - 1:30,000	Used for overview assessment of disasters involving a large area, some structural damage assessment, areas of inundation, accumulated rubble and brush, fire damage, and identification of safe or shelter areas.
1:30,000 - 1:50,000	Gross observations (most detail lost) may be used for pre-disaster planning, damage to transportation routes, and locating ponded water areas which might constitute a health hazard.

Photo interpreters commonly work from negatives or duplicate positives since it is time consuming to obtain prints and since some resolution is lost in going from a negative to a print. In some cases ground verification is necessary for questionable features on the photograph.

Black and white film is preferred for disaster damage assessment because it is the fastest means of obtaining useful results, i.e., it is quick to process relative to color and is easily reproducible. Other advantages are that it is less expensive than color and has a higher degree of resolution. The filter most commonly, if not exclusively, used by commercial survey companies is Kodak Wratten No. 12, medium yellow. This

filter may be used with all aerial films and is used 99% of the time on cameras in commercial use. It absorbs ultraviolet, violet, and all blue light (haze filter). Light yellow, No. 3, is never used by commercial companies but is sometimes used by the military for tests. It is used with panchromatic film and absorbs ultraviolet, violet and some blue light. Table 5 lists a number of films and filters available for commercial use.

Personnel and Equipment for Photo Interpretation

In order for photographs to be usable, they need to be interpreted. Photo interpreters are highly trained in the techniques of accurately identifying objects from their photographic images or signatures. All branches of the armed forces and most colleges and universities offer at least elementary instruction in photo interpretation. Most civilian photo interpreters are employed by aerial survey companies. Since there is not a significant difference between civilian and military environments in terms of signatures to identify on photographs, a trained photo interpreter from either source would be competent to interpret pre- and post-disaster photographs.

The following list includes the minimum equipment necessary to do photo interpretation:

1. lens or mirror stereoscope (assuming stereo photographs)
2. table magnifier
3. some type of measuring device (e.g., a photo interpretation slide rule)
4. maps or charts of the photographed area

Time and circumstance would dictate the necessity of more intricate equipment. A zoom transfer scope would be useful because it superimposes the

TABLE 5

DESCRIPTION OF FILMS AND FILTERS AVAILABLE FOR USE IN CAMERA SYSTEMS*

FILM TYPE	KODAK NAME	DESCRIPTION AND APPLICATION	AERIAL FILM SPEED	FILTERS AVAILABLE FOR USE WITH FILM
B & W 2402	PLUS-X AERO (Estar Base)	Medium grain, medium speed panchromatic negative film with medium-high contrast and extended red sensitivity. B & W prints or slides.	200	No. 12,15,16, 25,47B,58, HF-3
B & W 2403	TRI-X AERO (Estar Base)	Medium-grain, high speed panchromatic negative film with good image sharpness. Ideal low altitude, large scale photos under minimum light levels. B & W prints or slides possible. Too grainy for disaster assessment.	640	No. 12,15,16, 25,47B,58 H-3
R B & W 2424	INFRARED AERO (Estar Base)	Medium resolution, medium-grain, high contrast film sensitive to INFRARED and the visible spectrum. Requires use of filters. Has good haze penetration and is excellent for long oblique photography. Is NOT a thermal infrared film.	200	No. 25,89B
COLOR IR 2443	AEROCHROME INFRARED (Estar Base)	Medium resolution, medium speed COLOR positive film, sensitive to green, red, and infrared portions of the spectrum. The film is not designed to be used for thermal infrared photography. Filters must be used with film.	40	No. 12,15,16
COLOR NEG. 2445	AEROCOLOR NEGATIVE (Estar Base)	High speed, wide exposure latitude when processed to a negative. Direct interpretation can be made from negative, colors are direct complement to natural colors. Color prints, slides and B & W prints can be made.	100	No. 1-A,HF3, 2B#
COLOR POS. 2448	EKTACHROME AEROGRAPHIC MS (Estar Base)	Medium speed, fine-grain color positive film sensitive to visible light spectrum. Good image quality with excellent color rendition. Suitable for direct viewing and color prints can be made from the original.	32	No. 1-A,HF3
B & W 3411	PAN-X	Medium-grain, high contrast, extended red spectrum. Can be used when shadows are not a factor. High quality imagery.	200	No. 12,15,16, 25,47B,58,HF-3

*Source: The University of Kansas Space Technology Center. Amended by Lt. Commander Scott Ruby, Light Photographic Squadron 63, NAS Miramar, San Diego, California.

photograph onto a map base. This instrument has the capability of eliminating the basic distortions of aerial photography for subsequent map/photo registration, and it has an adapter to take a picture through the eyepiece lens which portrays the image as seen by the photo interpreter. A skilled cartographer would be of help in the preparation and rapid reproduction of maps. Other equipment that might prove useful to the photo interpreter includes:

Light table sized for film

Divider(s)

Plotting guides

Parallax bars

Zoom transfer scope

Zoom measuring macroscopes

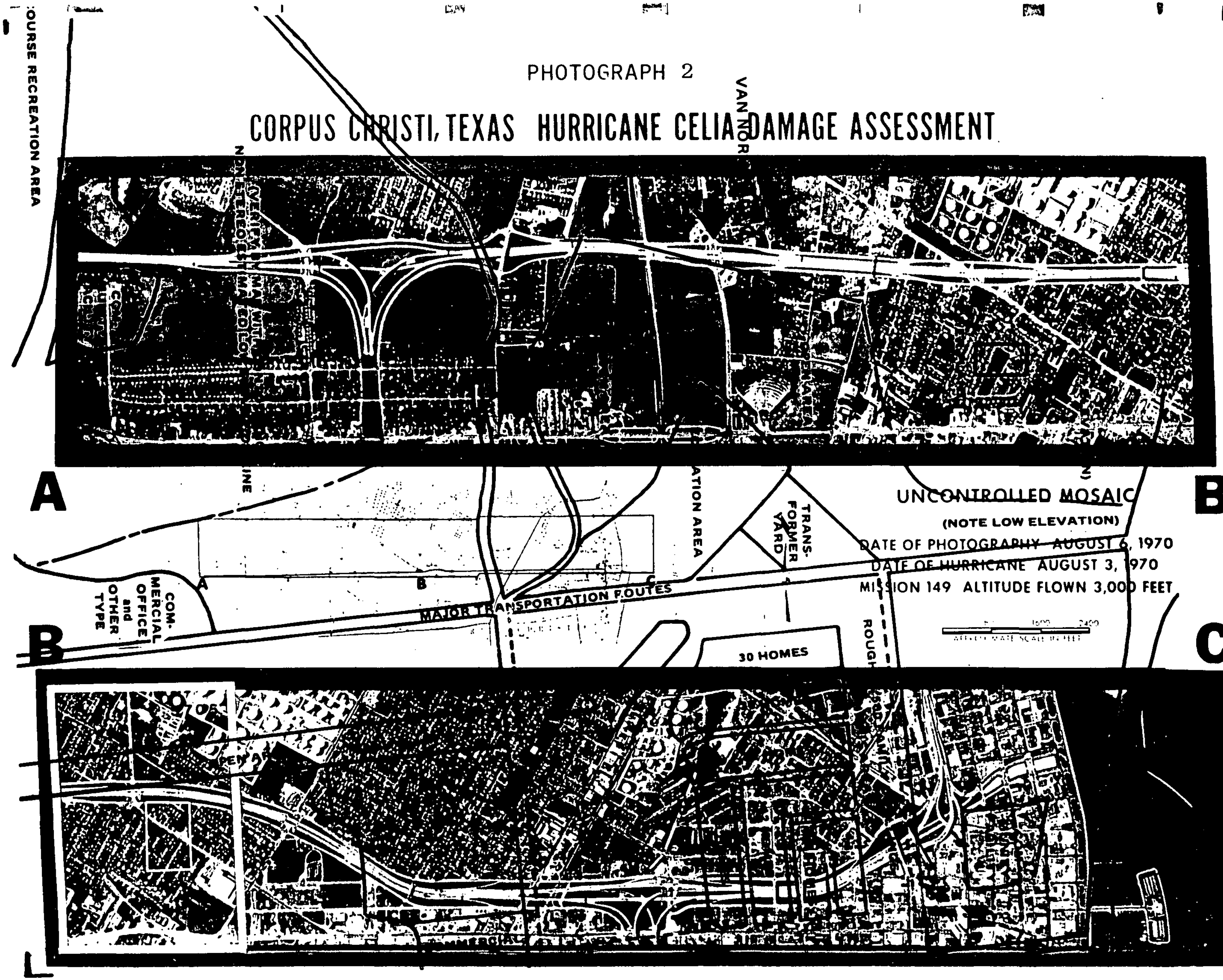
Ozalid machine for making overlays

Equipment to make a clear overlay from the frosted acetate

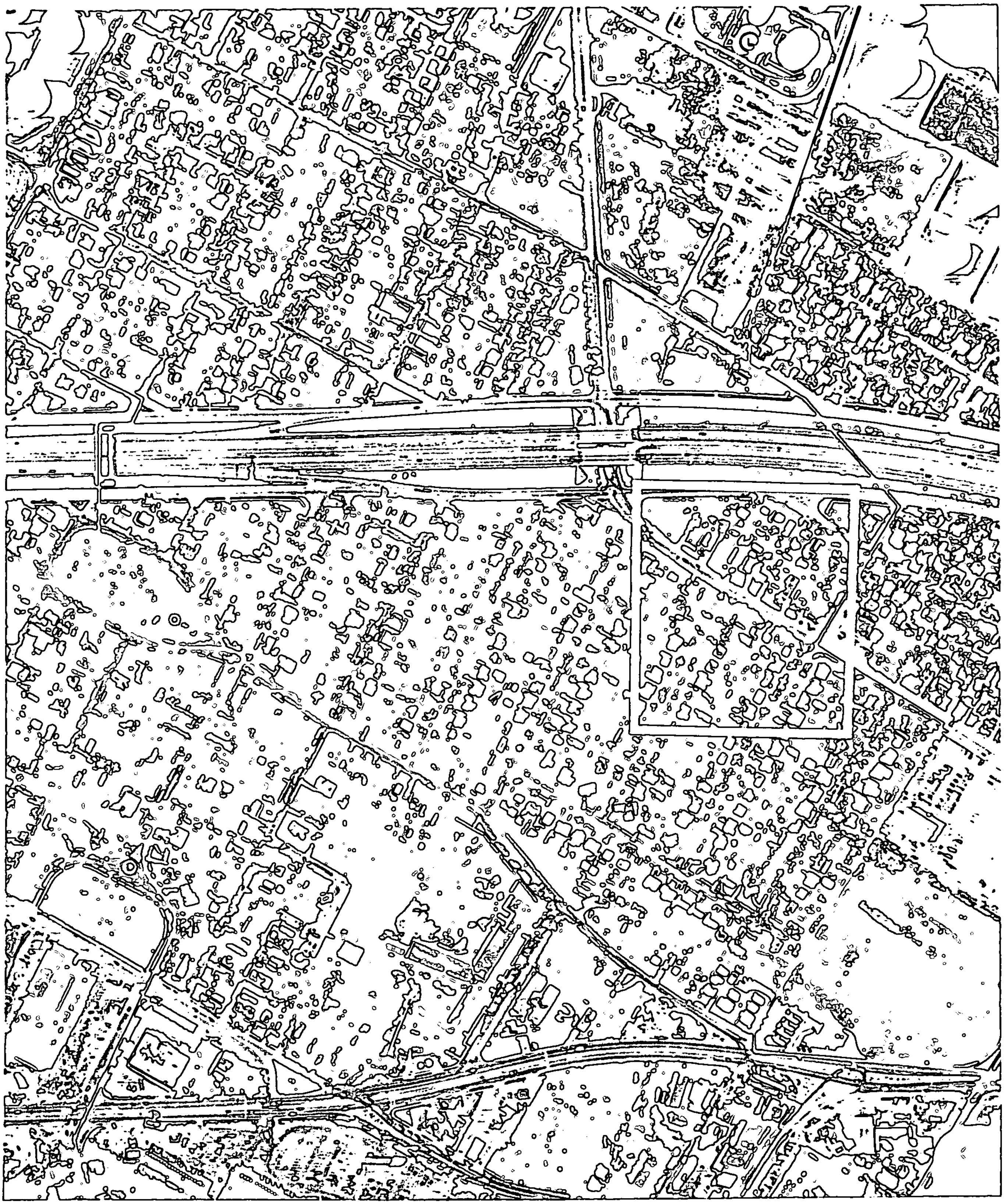
PHOTOGRAPH 1

PHOTOGRAPH 2

CORPUS CHRISTI, TEXAS HURRICANE CELIA DAMAGE ASSESSMENT



PHOTOGRAPH 3
CORPUS CHRISTI, TEXAS HURRICANE CELIA DAMAGE ASSESSMENT
FRAME 5705



PHOTOGRAPH 4
CORPUS CHRISTI, TEXAS HURRICANE CELIA DAMAGE
ENLARGEMENT OF SECTION OF FRAME 5705

PHOTOGRAPH 5
SAN FERNANDO, CALIFORNIA EARTHQUAKE